IMT SCHOOL FOR ADVANCED STUDIES LUCCA

IMT PhD Programs

Course List - A.Y. 2020/2021

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 3 specializing courses**

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Key:
C= Compulsory; S= Specializing; X= Elective; Free slots are "Also available"
***Imprendi 4.0 - Tuscan Start Up Academy (Project supported by Regione Toscana)**

Academic Year 2020/2021 - XXXVI Cycle			CCS		SS	
Courses	**Lecturer**	**Hours**	**AMCH**	**CCSN**	**CSSE**	**ENBA**
Advanced Methods for Complex Systems I	Diego Garlaschelli	20				S
Advanced Methods for Complex Systems II	Diego Garlaschelli	20				S
Advanced Methods for Complex Systems III	Tiziano Squartini	20				S
Advanced Neuroimaging	Giacomo Handjaras Nicola Vanello Mauro Costagli	34		X		
Advanced Numerical Analysis	Benedetta Morini Valeria Simoncini	20			X	
Advanced Seminars: Analysis and Management of Cultural Heritage (no exam)	Maria Luisa Catoni	30	C			
Advanced Topics in Archaeology I	Riccardo Olivito	10	C			
Advanced Topics in Archaeology II	Alessandro Poggio	10	C			
Advanced Topics in Cultural Heritage Law	Andrea Magliari	20	C			
Advanced Topics in Econometrics (esame facoltativo)	Francesco Serti	20				S
Advanced Topics in Islamic Cultural Heritage	Silvia Di Vincenzo	10	C			
Advanced Topics in Network Theory: Algebraic Concepts in Network Theory	Fabio Saracco	10				C
Advanced Topics in Network Theory: Brain Networks	Tommaso Gili	10				S
Advanced Topics in Network Theory: Dynamical Models in Network Theory	Rossana Mastrandrea	10				S
Advanced Topics in Network Theory: Research Topics in Network Theory	Tiziano Squartini	10				S
Advanced Topics in Network Theory: Topological Concepts in Network Theory	Angelo Facchini	10				S

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Academic Year 2020/2021 - XXXVI Cycle			CCS		SS	
Courses	**Lecturer**	**Hours**	**AMCH**	**CCSN**	**CSSE**	**ENBA**
Advanced Topics of Computational Mechanics	Marco Paggi Pietro Lenarda	20			X	
Analytics in Economics and Management*	Massimo Riccaboni	20				C
Applications of Stochastic Processes	Mirco Tribastone	20			X	S
Applied Data Science (no exam)	Francesco Serti Giorgio Gnecco	40				X
Basic Elements of Cybersecurity*	Rocco De Nicola	10			X	
Basic Linear Algebra and Statistics for Neuroscience	Giorgio Gnecco Francesco Serti	30		X		
Basic Principles and Applications of Brain Imaging Methodologies to Neuroscience	Emiliano Ricciardi Luca Cecchetti	52		C		
Basic principles and Applications of Electrophysiology and Stimulation Techniques	Giulio Bernardi Monica Betta Luca Turella Simone Rossi	52		C		
Basic Programming for Neuroscience	Monica Betta	20		X		
Behavioral Economics	Ennio Bilancini	20				S
Biosignals, Bionics and Neuroscience (long seminar without exam)	Michele Emdin Graziella Orrù Enzo Pasquale Scilingo Silvestro Micera Antonio Bicchi	28		X		
Business Model for Emerging Markets	Nicola Lattanzi	20				S
Clinical Psychopathology and Psychiatry	Pietro Pietrini	16		X		
Cognitive Economics	Gustavo Cevolani Luca Polonio	20		X		
Computational Contact and Fracture Mechanics	Marco Paggi	20			X	
Computer and Network Security	Gabriele Costa	20			X	
Computer Programming and Methodology	Mirco Tribastone	30			X	

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Academic Year 2020/2021 - XXXVI Cycle			CCS		SS	
Courses	**Lecturer**	**Hours**	**AMCH**	**CCSN**	**CSSE**	**ENBA**
Computer-Aided Engineering for Virtual Prototyping and Advanced Manufacturing Solutions	Marco Paggi Andrea Amicarelli	10			X	
Contextual Analysis and Individual Objects: Arts, Sciences, Techniques, Beliefs	Linda Bertelli	30	C			
Critical Thinking (no exam)	Gustavo Cevolani	20	X	X	X	X
Cultural Heritage and Law	Andrea Averardi	40	C			
Culture and Arts: Economic Analysis and Public Policy	Stefano Baia Curioni	25	C			
Data Analysis and Management for Cultural Heritage (no exam)	Raffaele Perego, Salvatore Orlando	20	C			
Decision-Making in Economics and Management (no exam)	Massimo Riccaboni	10	C			
East and West, Present and Past: The Cultural and Political Interplays between the Arabic World and Europe	Amos Bertolacci	45	C			
Econometrics 1	Paolo Zacchia	20				C
Econometrics 2	Armando Rungi	20				C
Evolutionary Game Theory	Ennio Bilancini	20				S
Experimental Economics	Chiara Nardi	20				X
Firms, Business Analytics and Managerial Behavior	Nicola Lattanzi	20				C
Forensic and Legal Psycology	Pietro Pietrini	16		X		
Foundations of Probability and Statistical Inference	Irene Crimaldi	30				S
Funding and Management of Research and Intellectual Property (no exam)	Marco Paggi	10	X	X	X	X
Game Theory	Ennio Bilancini	20				C
Geospatial approaches to cultural heritage (no exam)	Philip Verhagen	25	C			
Global Law	Andrea Averardi	10				X
History of Ancient Art and Archaeology	Maria Luisa Catoni	40	C			
History of Contemporary Art: Art History and Political History. Fascist Italy as a Case Study (no exam)	Michele Dantini	15	C			

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Academic Year 2020/2021 - XXXVI Cycle			CCS		SS	
Courses	**Lecturer**	**Hours**	**AMCH**	**CCSN**	**CSSE**	**ENBA**
History of Early Modern and Modern Art	Francesco Freddolini	30	C			
Identification, Analysis and Control of Dynamical Systems	Alberto Bemporad	20			X	
Industrial Organization	Massimo Riccaboni	20				S
Introduction to Cognitive and Social Neuroscience	Pietro Pietrini Emiliano Ricciardi	24		X		
Introduction to Consciousness and Sleep	Giulio Bernardi	20		C		
Introduction to Islamic Culture: Language, Religion, Challenges	Amos Bertolacci	15	X			
Introduction to Macroeconomics (c/o Scuola Sant'Anna)	Andrea Roventini	20				X
Introduction to Network Theory*	Guido Caldarelli	10				C
Introduction to Neuro-Linguistics	Alessandra Rampinini	12		X		
Introduction to Neuropsychology	Francesca Garbarini	12		X		
Introduction to Psychophysics	Davide Bottari	12		X		
Introduction to sustainability and ecological economics	Angelo Facchini	20				X
Machine Learning	Giorgio Gnecco	20			X	S
Management of Complex Systems: Approaches to Problem Solving	Andrea Zocchi Simone Gerola	40 40	C			
Markov Processes (c/o Scuola Sant'Anna)	Irene Crimaldi	12				X
Matrix Algebra	Giorgio Gnecco	10				X
Microeconomics	Kenan Huremovic Andrea Canidio	40				C
Model Predictive Control	Alberto Bemporad	20			X	
Modelling and Verification of Reactive Systems	Rocco De Nicola	20			X	
Models of Organization of Cultural Institutions	Paola Dubini	30	C			
Museology and History of Collecting	Emanuele Pellegrini	60	C			
Neurobiology of Emotion and Behavior	Pietro Pietrini	12		C		
Neuroeconomics	Luca Polonio	12		X		
Neuroscience of Perception and Experience-Dependent Plasticity	Emiliano Ricciardi Davide Bottari	48		C		

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Academic Year 2020/2021 - XXXVI Cycle			CCS		SS	
Courses	**Lecturer**	**Hours**	**AMCH**	**CCSN**	**CSSE**	**ENBA**
Numerical Methods for Optimal Control	Mario Zanon	30			X	
Numerical Methods for the Solution of Partial Differential Equations	Marco Paggi	20			X	
Numerical Optimization	Alberto Bemporad	20			X	
Optimal Control	Giorgio Gnecco	20			X	
Philosophical and Ethical Themes in Neuroscience (no exam)	Mirko Daniel Garasic	10		X		
Philosophy and Neuroscience in Moral Reasoning	Gustavo Cevolani	12		X		
Philosophy of Science (no exam)	Gustavo Cevolani	20	X	X	X	X
Political Economy	Alessandro Belmonte	20				S
Principles of Brain Anatomy and Physiology	Luca Cecchetti	30		C		
Principles of Concurrent and Distributed Programming	Rocco De Nicola Letterio Galletta	30			X	
Project Management	Beatrice Manzoni	35	C			
Qualitative and Quantitative Formal Methods for Computer Science	Rocco De Nicola Mirco Tribastone	20			X	
Research Seminars (no exam)	Pietro Pietrini, Emiliano Ricciardi	30		X		
Research Topics in Computer Science	Gabriele Costa	30			X	
Scientific Writing, Dissemination and Evaluation (no exam)	TBD	8	X	X	X	X
Socio-Economic Networks	Massimo Riccaboni	20				S
Software Verification	Gabriele Costa Letterio Galletta	20			X	
Stochastic Processes and Stochastic Calculus	Irene Crimaldi	20				S
Behavioral Strategy and Business Behavior	Nicola Lattanzi	20				S
Temporary Organizing and Event Management in Cultural and Creative Industries	Yesim Tonga Uriarte	10	C			

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.

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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

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Advanced Methods for Complex Systems III

Tiziano Squartini
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 course focuses on the problem of network reconstruction from partial topological information and on the different physical and mathematical properties found when the input information is treated as a "soft" or a "hard" constraint.
On the side of applications, emphasis will be put on the reconstruction of financial and interbank networks from node-specific properties, with the purpose of improving stress tests and systemic risk estimates in real markets and offering better tools to policy makers. The methods recently found by central banks to be the best-performing reconstruction techniques will be reviewed in detail.
On the side of theory, the surprising breakdown of the equivalence of statistical ensembles constructed from soft and hard constraints will be discussed. We will show how this breakdown affects all models of complex systems encountered throughout the three parts of the course. Finally, we discuss deep implications for data compression, information theory and combinatorial enumeration.

Lecture Contents:
- From binary networks to weighted networks: the Weighted Random Graph
- The Weighted Configuration Model
- The Enhanced Configuration Model
- The Enhanced Gravity Model
- Network reconstruction in various settings
- Adaptive Networks
- Breaking of ensemble equivalence
- Relative entropy between ensembles
- Weak and strong ensemble nonequivalence
- Applications to combinatorial enumeration and data compression

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 material 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, unlimited passion for theory. Successful completion of the courses "Advanced Methods for Complex Systems I" and "Advanced Methods for Complex Systems II"

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Advanced Neuroimaging
Giacomo Handjaras, Nicola Vanello, Mauro Costagli
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 Similaity Analysis.
Part 5. Trending methodologies to handle complex experiments (e.g., laminar fMRI, inverted encoding models).
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

(Nicola Vanello - 8 Hours)

Course description will be available soon.

(Mauro Costagli - 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
Benedetta Morini, Valeria Simoncini
20 Hours

(Benedetta Morini - 10 Hours)

Learning Outcomes:
At the end of the course the student will be able to use dense and sparse linear system solvers for medium to large size problems in standardly used scientific computational environment. The student will be able to select the appropriate methodology depending on the application considered, while being able to tailor general methods to the given problem.

Abstract:
We present an introduction to numerical linear algebra methods for solving algebraic linear systems, with particular focus on algorithms and their application. In particular, modern methods for dense and sparse matrices will be discussed, and state-of-the-art iterative methods for large problems will be introduced. The students will have the opportunity to test the discussed methods during computer lab sessions, working on real data.

Lecture Contents:
Direct methods for general linear systems:
Factorizations: definitions and properties
Factorization algorithms
Cost and numerical stability
Least-squares solution

Direct methods for sparse linear systems:
Factorizations of banded matrices
Ordering strategies to minimize the fill-in of a matrix
Solution of sparse triangular systems
Sparse matrices in Matlab: memorization and handling
Predefined functions for the direct solution of systems

Teaching Method:
Lectures and computer lab sessions.

Bibliography:
P. E. Gill, W. Murray, M. H. Wright, Numerical linear algebra and optimization, v.1
Numerical Linear Algebra and Optimization, Addison-Wesley Pub. Co., Advanced Book Program, 1991 (book)
T. A. Davis, Direct Methods for Sparse Linear Systems, SIAM, Series Fundamentals of Algorithms, 2006 (book)

Final Exam:
Oral presentation on a selected project possibly related to the student's interests.

Prerequisites:
None

(Valeria Simoncini - 10 Hours)

Course description will be available soon.

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

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Advanced Topics in Archaeology I
Riccardo Olivito
10 Hours

Learning Outcomes:
The aim of this course is to illustrate the different approaches that archaeologists have been using in dealing with space and place, their use, definitions, perceptions. In particular, it will focus on the theme of movement in the Ancient World.

Abstract:
Movement is a way to interact with the external world, independent from chronological and topographic boundaries. The physical placement of a body (both living and inanimate) in space, as well as the mental, emotional and sensational feedback associated with movement, are indeed keys to human interaction with external reality. Still, the way humans shape, perceive and interpret the external world is something deeply oriented by and depending on cultural, topographic and chronological factors. Moving on from recent scholarship on the theme, this course aims to illustrate and progress the recent research on movement and space in the Greek and Roman worlds, reflecting on the different levels of movement (walking, resting, weaving, sailing), as well as on different implications of movement (placement, displacement, orientation, disorientation, representation and conceptualization of movement).

Lecture Contents:
Shaping and Living the Space; Public spaces in the Ancient world and beyond; Between public and private sphere: the Roman domus; Movement and Space in the ancient World.

Teaching Method:
Lectures and in-class discussions

Bibliography:
Bibliography will be indicated at the beginning of each lesson.

Final Exam:
Seminar

Prerequisites:
None

Advanced Topics in Archaeology II
Alessandro Poggio
10 Hours

Learning Outcomes:
The course aims at offering critical skills to read ancient visual evidence in a cross-cultural perspective. Moreover, the course will make participants familiar with a wide set of methodologies in the field of archaeology, history of ancient art and cultural heritage.

Abstract:
Ancient artefacts have complex lives, which unfold from their production down to our times: looking at the many stages of an object's life provides a better understanding of its production context, circulation, reuses, post-antique receptions and interpretations. In other words, the study of ancient artefacts allows us to follow a colourful thread connecting different cultures across space and time.
The course intends to explore selected case studies related to the Ancient Near East and Greco-Roman Mediterranean, which provide a complex picture of artistic and cultural interactions through traditional and cutting edge methodologies. The starting point will be the material and visual aspects raised by the objects themselves, and a constant dialogue with contemporary theoretical frameworks will allow analysis not only of the original contexts of these artefacts, but also of their role in the present-day debate.
Off-site lectures may also be organised.

Lecture Contents:
After an introduction to the course, lectures will focus on selected case studies related to the Ancient Near East and Greco-Roman Mediterranean. The analysis of this evidence will take into account both traditional and cutting edge methodologies in order to shed light on pivotal episodes of connection between different cultures across space and time.

Teaching Method:
Lectures – In-class discussions – Assignments – Field trips

Bibliography:
Bibliography will be provided by the lecturer. Students interested in specific issues are invited to request bibliographical references.

Final Exam:
Seminar

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

Lecturer: Francesco Serti
Hours: 20

Learning Outcomes:
The aim of the module is to bridge the step from a technical econometrics course to doing applied research. The emphasis will be on the application of the methods, rather than the technical details about them. As such, the goal is to provide students with enough knowledge to understand when these techniques are useful 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 will be illustrated using theory and papers drawn from the recent applied literature.

Lecture Contents:
1 Causality and Randomized Experiments
- a) Structural and Treatment Effects approaches
- b) Basic questions in empirical research
- c) Rubin Causal model
- d) Social Experiments
- e) Application I: Krueger (1999) on class size and educational test scores
- f) Application II: Atkin et al. (2017) on exporting and firm performance: evidence from a randomized experiment

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) Application III: Miguel et al (2004) on rainfall, economic growth and conflict
- g) Application IV: Nunn (2009) on slave trades and economic performances

4 Matching
- a) Covariate Matching
- b) Propensity Score Matching
- c) Inverse Probability Weighting
- d) Entropy balancing

e) Regression adjustment
f) Application V: Angrist (1998) on the labor market impact of voluntary military service (matching meets regression)
g) Application VI: Dehejia and Wahba (1999) on Causal Effects in Non-Experimental Studies: Re-Evaluating the Evaluation of Training Programs.

5 Differences-in-Differences
a) Basics
b) Regression Differences-in-Differences
c) Robustness checks and picking a good control group
Application VII: Card & Krueger (1994) on minimum wage and unemployment

6 Regression Discontinuity Design
a) Sharp RD
b) Fuzzy RD
c) Running RD Models
d) Application VIII: Lee (2008) on U.S. House elections
e) Application IX: Angrist & Lavy (1999) on scholastic achievement

7 The Synthetic Control Method
a) Basics
b) Multiple treated units
c) Robustness checks and inference
d) Application X: Abadie et al. (2010) on the Effect of California's Tobacco Control Program
e) Application XI: Campos et al (2018) on institutional integration and economic growth in Europe

Teaching Method:
The emphasis will be on the application of the methods, rather than the technical details about them. After a review of the theory behind each empirical method, we will focus on their practical implementation and on some examples from the applied economic literature.

Bibliography:
Angrist, Joshua D. and Pischke, Jorn-Steffen. (2009). Mostly Harmless Econometrics: An Empiricist's Companion, Princeton University Press.

Final Exam:
The assessment is based on the production of a short empirical essay. To do the project students will need to provide a clear research question and a feasible empirical strategy; collect relevant data; implement an appropriate method chosen among one of those explored in the module; draw conclusions and write up the results in a standard academic style in less than 3,000 words.

Prerequisites:
None

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Advanced Topics in Islamic Cultural Heritage
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

Advanced Topics in Network Theory: Algebraic Concepts in Network Theory
Fabio Saracco
10 Hours

Learning Outcomes:
THE STUDENT WILL ACQUIRE THE ALGEBRAIC SKILLS TO OPERATE WITH NETWORKS

Abstract:
we shall provide the definitions of the algebraic concepts lying at the core of network theory and shall introduce the principles of network analysis with Python. This module is propedeutic for modules 3, 4, 5.

Lecture Contents:
LECTURE 11 Graph Representation
LECTURE 12 Graph Representation
LECTURE 13 Exercises in Python
LECTURE 14 Graph Laplacian
LECTURE 15 Graph Spectral properties
LECTURE 16 Exercises in Python
LECTURE 17 Exercises in Python
LECTURE 18 Exercises in Python
LECTURE 19 Exercises in Python
LECTURE 20 Exercises in Python

Teaching Method:
Powerpoint lectures

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

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Advanced Topics in Network Theory: 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

Advanced Topics in Network Theory: Dynamical Models in Network Theory
Rossana Mastrandrea
10 Hours

Learning Outcomes:
Being able to use models for network theory

Abstract:
we shall review the most popular growth models for networks, the details of the most studied dynamical processes on networks and their implementation in Python. This module requires module 2.

Lecture Contents:
LECTURE 31 Models I
LECTURE 32 Models II
LECTURE 33 Models III
LECTURE 34-37 Epidemics
LECTURE 37-40 Exercises in Python

Teaching Method:
Powerpoint lectures

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

Advanced Topics in Network Theory: Research Topics in Network Theory
Tiziano Squartini
10 Hours

Learning Outcomes:
Being aware of the state of the art

Abstract:
We shall review the latest developments in research concerning the field of network theory. This module requires module 2. The course "Advanced Methods for Complex Systems I" is suggested as a prerequisite.

Lecture Contents:
The Exponential Random Graph Model: constrained entropy maximization; parameter estimation; computing expectations and errors; a quick look at perturbation theory for networks (2h)
Hypothesis testing on networks: projecting and filtering bipartite networks; early-warning signals detection; community detection techniques for correlation matrices (asset graph, MSF, dendrogram-cutting, the Masuda approach, random matrix theory-based techniques) (3h)
Network reconstruction; applications to the World Trade Web; comparison between network models and econometric models; applications to financial networks; link prediction (3h)
An overview of infrastructural networks (2h)

Teaching Method:
Powerpoint lecture

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

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Advanced Topics in Network Theory: Topological Concepts in Network Theory
Angelo Facchini
10 Hours

Learning Outcomes:
knowledge of the topology associated to graphs

Abstract:
we shall introduce the definitions of the main topological quantities of interest in network theory and their implementation in Python. This module requires module 2 and is propedeutic for module 5.

Lecture Contents:
LECTURE 21 Centrality measures II
LECTURE 22 Centrality measures
LECTURE 23 Bipartite Networks
LECTURE 24 Ranking and Reputation
LECTURE 25 Mesoscale Properties
LECTURE 26 Exercises in Python
LECTURE 27 Exercises in Python
LECTURE 28 Trade Network data
LECTURE 29 Exercises in Python
LECTURE 30 Exercises in Python

Teaching Method:
Powerpoint lectures

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

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Advanced Topics of Computational Mechanics
Marco Paggi, Pietro Lenarda
20 Hours

Learning Outcomes:
Overview of interdisciplinary frontier research topics where computational methods can be profitably applied as predictive simulation tools. Nonlinear coupled problems in solid mechanics and fluid dynamics problems in biomechanics will be the main object of the lectures.

Abstract:
This course covers advanced topics of computational mechanics, with special emphasis on nonlinear coupled problems in solid mechanics and fluid dynamics. This course aims at providing an overview of frontier research topics in emerging interdisciplinary areas where computational methods can be profitably applied as predictive simulation tools.

Lecture Contents:
The course content covers the following topics:
- Advanced techniques for solid mechanics and fluid dynamics;
- Coupled problems in biomechanics;
- Coupled problems for renewable energy applications;
- Computational methods for the prediction of the evolution of discrete mechanical systems and interdisciplinary analogies (traffic networks, economic networks, etc.)

Teaching Method:
Lectures using powerpoint slides.

Bibliography:
Selection of scientific articles published in international journals.

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:
Bibliographic material will consist of research articles distributed throughout the course.

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

Prerequisites:
None

Applied Data Science
Francesco Serti, Giorgio Gnecco
Hours: 40

(Econometrics part - Francesco Serti - 20 Hours)

Learning Outcomes:
(1) Knowledge of the most relevant functionalities in Stata to carry out data management and exploratory analysis
(2) To achieve autonomy in application of econometric techniques to real data

Abstract:
The aim of this course is to provide students with fundamentals of Stata language to conduct data management and exploratory analysis, and implement a variety of econometric techniques to address typical research questions in Economics.

Lecture Contents:
Lectures will cover the following topics:
- Introduction to Stata, descriptive statistics, fundamentals of inference
- OLS regression
- Panel methods (pooled OLS, Fixed Effects, Random Effects, First Difference, Generalized Least Squares)
- Impact Evaluation (Randomized experiments, Matching, Difference-in-differences, Instrumental Variables, Regression Discontinuity Design, Synthetic Control Methods)
- Total Factor Productivity estimation

Teaching Method:
Computer-based

Bibliography:
Angrist, J. D., and J. S. Pischke (2008) Mostly harmless econometrics: An empiricist's companion. Princeton University Press.
Cameron, A. C., P. K. Trivedi (2009) Microeconometrics Using Stata. Stata Press.
Wooldridge, J. M. (2010) Econometric Analysis of Cross Section and Panel Data. MIT Press.

Final Exam:
There will be no exam

Prerequisites:
None

(Machine Learning part - Giorgio Gnecco - 20 Hours)

Learning Outcomes:
At the end of the course, the student will be able to implement in MATLAB some machine learning techniques, including ones studied during the course "Machine Learning".

Abstract:
The course provides MATLAB implementations of some machine learning techniques, including ones studied during the course "Machine Learning".

Lecture Contents:
MATLAB code will be presented and discussed for the following studies:
- bias/variance trade-off;
- batch gradient descent and stochastic gradient descent for training perceptrons and multilayer neural networks;
- perceptrons and multilayer neural networks applied to the XOR problem;
- multiclass classification via neural networks;
- LQG online learning;
- trade-off between number of examples and precision of supervision in ordinary least squares, weighed least squares, and fixed effects panel data models;
- spectral clustering;
- surrogate optimization for optimal material design;
- box identification via the Monte Carlo method;
- curve identification.

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 following reference reports commented MATLAB code for some of the machine-learning applications presented in the course:
P. Kim, "MATLAB Deep Learning With Machine Learning, Neural Networks and Artificial Intelligence," Apress, 2017.

The MATLAB code for most of the other applications is related to the following articles:
A. Bacigalupo, G. Gnecco, M. Lepidi, L. Gambarotta, "Machine-learning techniques for the optimal design of acoustic metamaterials," Journal of Optimization Theory and Applications, 2019, DOI: 10.1007/s10957-019-01614-8.
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, "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, A. Bemporad, M. Gori, M. Sanguineti, "LQG online learning," Neural Computation, vol. 29, pp. 2203-2291, 2017.
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:
None

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Basic Elements of Cybersecurity
Rocco De Nicola
10 Hours

Learning Outcomes:
Basic knowledge of the risks when surfing the web and of the main tools for defending assets and privacy.

Abstract:
This introductory an introductory course that would be beneficial for any student and does not assume any prior technical knowledge. We will discuss cybersecurity in general and present techniques and tools for navigating securely and for defending assets and privacy.

Lecture Contents:
Introduction to Cybersecurity, examples of different kinds of attacks. Best practice for malware detection and for password management. Secure and privacy preserving Internet surfing and application usage. Introduction to Access Control methods. Basic notions of cryptography: Symmetric and Asymmetric Encryption, Public-Key Encryption, Message Authentication, Digital Signatures. Steganography.

Teaching Method:
Blackboard; slides.

Bibliography:
Handouts with the slides, introductory books,

Final Exam:
Final collective discussion about the importance of cybersecurity with short presentations by all students.

Prerequisites:
None

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
52 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.

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

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 Techniques
Giulio Bernardi, Monica Betta, Luca Turella, Simone Rossi
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.

(Luca Turella - 8 Hours)

Learning Outcomes:
The objective of the course is to provide the students with the following competences:
- Knowledge of the main topics in MEG research
- Knowledge of the advanced experimental techniques and methods specific to this methodology
- Ability to define formulate specific experimental design to answer experimental questions exploiting the specific feature of MEG
- Ability to critically understand experimental data and results for MEG

Abstract:
This course provides a comprehensive overview of MEG research and of recent advances in this field.
In detail, we will cover the peculiarity of MEG with respect to other neuroimaging techniques. From the analytical point of view, we will introduce concepts related to time-frequency analysis, multivariate approaches and connectivity measures. Moreover, we will also discuss how MEG might be combined with other methodologies.

Lecture Contents:
This course provides a comprehensive overview of the core topics in MEG research.

Teaching Method:
The course is lecture-based.

Bibliography:
General Introduction to MEG
Baillet, S., 2017. Magnetoencephalography for brain electrophysiology and imaging. Nat. Neurosci. 20, 327–339. https://doi.org/10.1038/nn.4504
Gross, J., 2019. Magnetoencephalography in Cognitive Neuroscience: A Primer. Neuron 104, 189–204. https://doi.org/10.1016/j.neuron.2019.07.001
Lakatos, P., Gross, J., Thut, G., 2019. A New Unifying Account of the Roles of Neuronal Entrainment. Curr. Biol. 29, R890–R905. https://doi.org/10.1016/j.cub.2019.07.075
Optically-pumped MEG
Boto, E., Holmes, N., Leggett, J., Roberts, G., Shah, V., Meyer, S.S., Muñoz, L.D., Mullinger, K.J., Tierney, T.M., Bestmann, S., Barnes, G.R., Bowtell, R., Brookes, M.J., 2018. Moving magnetoencephalography towards real-world applications with a wearable system. Nature 555, 657–661.

https://doi.org/10.1038/nature26147

Multivariate approaches using MEG
Cichy, R.M., Pantazis, D., Oliva, A., 2014. Resolving human object recognition in space and time. Nat. Neurosci. 17, 455–462. https://doi.org/10.1038/nn.3635
King, J.R., Dehaene, S., 2014. Characterizing the dynamics of mental representations: The temporal generalization method. Trends Cogn. Sci. 18, 203–210. https://doi.org/10.1016/j.tics.2014.01.002

Combining neurostimulation with neuroimaging
Bergmann, T.O., Karabanov, A., Hartwigsen, G., Thielscher, A., Siebner, H.R., 2016. Combining non-invasive transcranial brain stimulation with neuroimaging and electrophysiology: Current approaches and future perspectives. Neuroimage 140, 4–19. https://doi.org/10.1016/j.neuroimage.2016.02.012

Final Exam:
The evaluation of the student will consider the participation during the discussions.

Prerequisites:
None

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(Simone Rossi -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
20 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.

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Biosignals, Bionics and Neuroscience
Michele Emdin, Graziella Orrù, Enzo Pasquale Scilingo, Silvestro Micera, Antonio Bicchi
28 Hours

(Michele Emdin 6 – Hours)
(Graziella Orrù 6 – Hours)
(Enzo Pasquale Scilingo 6 – Hours)

Course description will be available soon.

(Antonio Bicchi 6 – Hours)

Learning Outcomes:

The objective is to introduce students to the design, integration and use of bionic devices for prosthetics and rehabilitation, at the intersection of multiple disciplines which contribute to these processes – from neuroscience to engineeing and to clinical assessment.

Abstract:

In the six lectures, I will introduce some of the ideas that underpin modern research in bionic systems, which draw on one side from neuroscientific principles of motor control and cognitive neuro-rehabilitation, and on the other side from modern robotics technologies and artificial intelligence. The multidisciplinary approach will be illustrated using examples and case studies in haptic rendering of contact information, prosthetics, and rehabilitation.

Lecture Contents:

1) Haptics: how understanding the sense of touch helps developing devices to displays haptic information
2) Human and Artificial Hands: how understanding motor control helps the development of better robotic technology
3) Natural Bionic Devices for prosthetics and post-stroke rehabilitation

Teaching Method:

Classes will be given in person, with slides to show images and videos. Live demonstrations of rehabilitation devices and prcodeures will be given

Bibliography:

A. Moscatelli, Bianchi, M., Serio, A., Terekhov, A., Hayward, V., Ernst, M., and Bicchi, A., "The Change in Fingertip Contact Area as a Novel Proprioceptive Cue", *Current Biology*, vol. 26, no. 9, pp. 1159–1163, 2016
[Open Access]. Available: http://www.sciencedirect.com/science/article/pii/S0960982216301348

M. Santello, Bianchi, M., Gabiccini, M., Ricciardi, E., Salvietti, G., Prattichizzo, D., Ernst, M., Moscatelli, A., Jorntell, H., Kappers, A., Kyriakopulos, K., Albu-Schaeffer, A., Castellini, C., and Bicchi, A., "Hand synergies: Integration of robotics and neuroscience for understanding the control of biological and artificial hands", *Physics of Life Reviews*, vol. 17, pp. 1-23, 2016
[Open Access]. Available: http://www.sciencedirect.com/science/article/pii/S1571064516000269

A. Leo, Handjaras, G., Bianchi, M., Marino, H., Gabiccini, M., Guidi, A., Scilingo, E. P., Pietrini, P., Bicchi, A., Santello, M., and Ricciardi, E., "A synergy-based hand control is encoded in human motor cortical areas", *eLIFE*, 2016 [Open Access]. Available: http://elifesciences.org/content/5/e13420v2

A. S. Ciullo, Veerbeek, J. M., Temperli, E., Luft, A. R. L., Tonis, F., Haarman, C., A. Ajoudani, Catalano, M. G., Held, J., and Bicchi, A., "A Novel Soft Robotic Supernumerary Hand for Severely Affected Stroke Patients", *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, vol. 28, no. 5, 2020 [Open Access]. Available: https://ieeexplore.ieee.org/document/9051797

Final Exam:
No exam.

Prerequisites:
No specific skill is assumed.

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

(Silvestro Micera - 4 Hours)

Learning Outcomes:
The students will gather a general introduction about neuroengineering and its potentials for different applications.

Abstract:
Neuroengineering is a novel discipline combining engineering including micro and nanotechnology, electrical and mechanical, and computer science with cellular, molecular, cognitive neuroscience with two main goals: (i) increase our basic knowledge of how the nervous system works; (ii) develop systems able to restore functions in people affected by different types of neural disability. In the past years, several breakthroughs have been reached by neuroengineers in particular on the development of neurotechnologies able to restore sensorimotor functions in disabled people.

Lecture Contents:
Introduction to Neuroengineering
Bidirectional brain-computer interfaces
Implantable system to restore sensory-motor functions in disabled people
Bioelectronic Medicine

Teaching Method:

Bibliography:

Final Exam:
No exam.

Prerequisites:
None.

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, Gustavo Cevolani
20 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.

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. These include dual-process theories of reasoning and cognition, the process tracing approach, and different models of choice, such as drift diffusion and rational inattention models. Moreover, the course aims to provide a practical understanding of different methods from psychophysics, including the analysis of reaction time, mouse-lab and eye-tracking, enabling students to design their own experiments.

Lecture Contents:
1) What is Cognitive Economics
2) Approaches in Cognitive Economics and Cognitive Science
3) Rationality, Reasoning and Decisions: Theory and Practice
4) The Role of Cognitive Abilities in Decision Making
5) Methods from psychophysics for the investigation of decision making (analysis of reaction time, mouse-lab and eye-tracking)
6) Bounded Rationality and Social Preferences
7) The Role of Emotions in Decision Making
8) Drift diffusion and rational inattention 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.

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;
- applications of fracture mechanics to materials science, retrofitting of civil/architectonic structures, composite materials;
- fatigue.

Teaching Method:
Lectures using blackboard and powerpoint slides.

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

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 and Network Security
Lecturer: Gabriele Costa
Hours: 20

Learning Outcomes:
The general understanding of the threats and methodologies. Students will learn the theoretical foundation behind software, network and computer (in)security. Moreover, they will practice with actual tools and research prototypes that implement recently proposed techniques.

Abstract:
"What might go wrong?" that is the main question of cybersecurity. Needless to say, answering this question is extremely complex. Systems are usually designed to do something specific, but the things they should not do are usually many (!) more. In this course we will consider the relevant attacker models and the existing methodologies for detecting vulnerabilities, preventing exploits and mitigating attacks. This will be achieved by combining the most theoretical aspects behind system modelling and analysis with practical experiences on real tools and systems.

Lecture Contents:
Preliminaries about theoretical aspects of computer science
Attacker modeling
- vulnerabilities
- exploits
- attack strategies
- APTs

Protocol and network security
- security protocols
- protocol modelling an verification

Software security
- Security testing
- Static analysis

Teaching Method:
Theory and practice with hands-on activity

Bibliography:
RTFM: red team field manual

Final Exam:
Project or seminar

Prerequisites:
None

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

Computer-Aided Engineering for Virtual Prototyping and Advanced Manufacturing Solutions
Marco Paggi, Andrea Amicarelli
10 Hours

Learning Outcomes:
Overview of Computer-Aided Engineering (CAE) software for solid and fluid dynamics; CAD-CAE integration software; overview of fast prototyping solutions with examples of high industrial relevance.

Abstract:
This course aims at introducing doctoral students to the state-of-the-art of methods and tools of Computer-Aided Engineering (CAE), which refers to the broad use of computer software to aid in engineering design tasks. It encompasses finite element analysis (FEA), computational fluid dynamics (CFD), analysis tools for industrial process simulation, multi-physics simulation software for smart systems, and also platforms allowing the integration with control and optimization for the product or process. This field is one of the pillars of Industry 4.0, since it allows for virtual testing and virtual and rapid prototyping of materials, components and processes, reducing the time to market of new products and leading to higher levels of performance and reliability.

Lecture Contents:
The course covers the following content:
- Overview of Computer-Aided Engineering software, with special focus on finite element analysis and computational fluid dynamics tools.
- Overview of techniques for CAD-CAE integration, including isogeometric finite elements.
- Overview of 3D prototyping techniques.
- Introduction to CFD Smoothed Particle Hydrodynamics software (SPHERA).
- High-performance computing techniques for the analysis of industrial problems.

Teaching Method:
Powerpoint presentations.

Bibliography:
Handouts are provided to the participants.

Final Exam:
The final exams consists of an application of one of the taught methodologies to a case study of interest for the PhD students' research.

Prerequisites:
It could be useful to attend the course on Numerical Methods for the Solution of Partial Differential Equations. However, the present course is self-contained.

Contextual Analysis and Individual Objects: Arts, Sciences, Techniques, Beliefs
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:

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- 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.
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- Edwards, E., Anthropology and photography 1860-1920. New Haven: Yale University Press, 1992.
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- 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 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, lies, misinformation, disinformation, post-truth, fake news, rumors, etc.) and with common reasoning pitfalls, heuristics and biases as investigated in cognitive psychology and behavioral economics.

Lecture Contents:
Lecture 1. Presentation, discussion and choice of specific topics. Arguments and statements.
Lecture 2. Evaluating statements: Truth, certainty, informativeness, truthlikeness, etc. Relativism and post-truth.
Lecture 3. Evaluating arguments: Deductive reasoning and valid arguments. Fallacies and invalid arguments.
Lecture 4. Evaluating arguments: Non-deductive and uncertain reasoning. Inductive and abductive reasoning.
Lecture 5. Evaluating arguments: Probabilistic reasoning and confirmation. Correlations.
Lecture 6. Reasoning and decision-making: Dual-process theories. Heuristics and biases.
Lecture 7. Reasoning and decision-making: Ecological rationality and fast-and-frugal heuristics.
Lecture 8. Recap, verification and general discussion.

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 the IMT Google Drive. The following are useful general texts on the main topics of the course (all of them are owned by the IMT Library).

- Ronald N. Giere, John Bickle, and Robert Mauldin (2005). Understanding Scientific Reasoning. Wadsworth Inc Fulfillment.

- Gerd Gigerenzer (2008). Rationality for Mortals: How People Cope with Uncertainty. Oxford and New York: Oxford University Press
- Hacking, Ian (2001). An Introduction to Probability and Inductive Logic. New York: Cambridge University Press.
- Darrell Huff (1993). How to lie with statistics. New York: Norton
- Daniel Kahneman (2011). Thinking, Fast and Slow. 1st edition. New York: Farrar, Straus and Giroux
- Richard E. Nisbett (2015). Mindware: Tools for Smart Thinking. New York: Farrar, Straus and Giroux
- Merrilee H. Salmon (2013). Introduction to Logic and Critical Thinking. 6th ed.
- Wesley C. Salmon (1963). Logic. Englewood Cliffs, N.J., Prentice-Hall
- Cass R Sunstein (2009). On Rumors: How Falsehoods Spread, Why We Believe Them, What Can Be Done. New York: Farrar, Straus and Giroux

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
40 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

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Data Analysis and Management for Cultural Heritage
Raffaele Perego, Salvatore Orlando
20 Hours

Learning Outcomes:
The students will understand techniques and methodologies for the organization and management of structured and unstructured digital data for the Cultural Heritage field.

Abstract:
The goal of the proposed PhD course is to introduce the main techniques for creation and management of complex digital data that can be used by innovative applications in the Cultural Heritage (CH) field and the GLAMs (i.e.. Galleries, Libraries, Archives and Museums).
Specifically, the course aims at introducing state-of-the-art techniques and methodologies for the organization and management of structured and unstructured digital data - namely databases and information retrieval, semantic web, data and text mining - as well as systems and applications for CH that exploit the so-called wisdom of the crowds, engaged through platforms of crowdsourcing and serious games, for managing CH digital data and boosting the impact of GLAMs activities on various stakeholders, e.g., tourists, government, scholars, etc.
Benefits deriving from this course are mainly three: awareness about the main technologies to organize and manage GLAMs' data and objects efficiently, practical examples of how to turn these data and objects into knowledge to be successively exploited, learn how to exploit people and visitors to improve the quality of GLAMs' offered services.

Lecture Contents:
- Basic introduction to Data Management (databases, etc.)
- Basic introduction to Information Retrieval
- Web Databases, Digital Libraries, and Search Engines
- Digital Images, Human vs. Machine Perception and Similarity Search
- Monitoring and profiling users' behaviour
- Data Mining
- Entity Extraction, Linking, Classification, and Tagging
- Semantic Web: Open Linked Data for Cultural Heritage
- Introduction to the Wisdom of the Crowds: Crowdsourcing in the cultural heritage domain - Games With a Purpose (GWAP) - Examples

Teaching Method:
Conventional, with small lab sessions.

Bibliography:
Lecture notes.

Final Exam:
No final exam.

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Prerequisites:
None.

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

East and West, Present and Past: The Cultural and Political Interplays between the Arabic World and Europe
Amos Bertolacci
45 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 1
Paolo Zacchia
20 Hours

Learning Outcomes:
The objective of the course is to provide a firm understanding of the core theory of Econometrics at the graduate level.

Abstract:
This course provides a general introduction to modern econometrics. Following a review of fundamental concepts of probability theory, the course illustrates the fundamental linear and non-linear models at the core of econometrics, under the unifying framework of Maximum Estimation. Emphasis is placed upon the concepts of structure, identification, causality; their mutual relationships; as well as their connection to the actual econometric practice.

Lecture Contents:
1) Probability Review
2) Asymptotics Review
3) Structure, Identification and Causality
4) The Linear Regression Model
5) Least Squares Estimation
6) Endogeneity and Instrumental Variables
7) Simultaneous Equations Model
8) Introduction to Maximum Estimation
9) Maximum Likelihood Estimation
10) Generalized Method of Moments

Teaching Method:
Traditional frontal instruction accompanied by optional practice hours

Bibliography:
A. Colin Cameron and Pravin K. Trivedi (2005), Microeconometrics: Methods and Applications, Cambridge University Press
William H. Greene (2012), Econometric Analysis, Pearson
Marno Verbeek (2012), A Guide to Modern Econometrics, Wiley
Other notes and scientific articles will be distributed in class

Final Exam:
The assessment is based upon a final written exam (for about 70% of the final grade) as well as on two extensive problem sets (for about the remaining 30%).

Prerequisites:
Multivariate calculus, linear algebra, graduate-level probability and statistical inference.

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Econometrics 2
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:
This 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. 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. 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%).

Lecture Contents:
1) Introduction to Microeconometrics
   i) eterogeneity and Microdata
   ii) The Potential Outcome Model
   iii) Exogeneity and Identification
   iv) Parametric, Semiparametric and Non-parametric Models
   v) The Local Polynomial Regression Model
   vi) The Kernel Density Estimation

2) Survey Design, Sampling and Variance
   i) Survey design and Sampling Techniques
   ii) The Heckman Correction
   iii) One-way and Two-way Analysis of Variance
   iv) Analysis of Covariance

3) Linear Panel Models
   i) Pooled Models
   ii) The Fixed Effects Estimator
   iii) The Random Effects Estimator
   iv) Mixed Models
   v) GMM Estimators for Panel Data
   vi) Application: Firms, Productivity and Technical Change (Industrial Organization)

4) The Evaluation Problem
   i) Randomized Experiments
   ii) Matching Models
   iii) The Difference-in-difference Estimators

iv) Instrumental Variables
v) Regression Discontinuity Design
vi) Models with Control Functions
vii) Application: Evaluation of Active Labor Markets Programs (Labor economics)

5) Repeated Measures and Longitudinal Designs
i) Experiments and Quasi-experiments
ii) Longitudinal Designs and Repeated Measures
iii) Between-subjects Hypothesis Testing
iv) Application: Behaviorally Motivated Policies (Behavioral/Experimental Economics)

6) Multinomial Models
i) A Review of Logit and Probit Models
ii) The Multinomial Logit Model
iii) The Conditional Logit Model
iv) The Nested Logit Model
v) The Ordered Probit Model
vi) Application: Location Choices and Agglomeration Economies (Economic Geography)

7) Models for Count Data
i) Poisson Regression Model
ii) Negative Binomial Regression Model
iii) Hurdle Models
iv) Application: Technology Diffusion with Patent Data (Economics of Innovation)

8) Survival/Duration Models
i) On Censoring and Truncation
ii) The Kaplan-Meier Curve
iii) The Cox Regression Model
iv) The Weibull Model
v) Application: Market Access for Pharmaceutical Products (Health Economics)

9) Special seminar: Econometrics and Machine learning

Teaching Method:
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

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 Statistics; 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.

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 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.)

Teaching Method:
Powerpoint slides

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 strategic behavior.

Abstract:
The course begins by providing a detailed discussion of the state of the art approach to the modeling of strategic situations as games. Then, basic solution concepts and their main refinements will be reviewed. Finally, prominent applications concerning incomplete and asymmetric information will be presented.

Lecture Contents:
Game concepts covered:
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 economics and the social and behavioral sciences.

Teaching Method:
Frontal lectures

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

Final Exam:
1/3 assignments, 1/3 final written exam, 1/3 essay

Prerequisites:
The course is self-contained, but being familiar with basic concepts from calculus, l inear algebra, and probability theory is quite helpful.

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Geospatial Approaches to Cultural Heritage
Philip Verhagen
25 Hours

Learning Outcomes:
Upon completing this course, students will have obtained a broad, comprehensive overview of geospatial approaches to cultural heritage. They will be able to do the basics of setting up, analysing and presenting geospatial datasets, and to reflect on the impact of geospatial approaches on heritage research and management.

Abstract:
Geospatial data provide essential information on numerous aspects of cultural heritage and landscape. They are increasingly available at all levels of detail, and can be combined with other sources of information to generate new, spatial knowledge about the past and its relationship to the present.

In this course, you will be confronted with a broad range of geospatial approaches applied to cultural heritage. Starting from the technical and theoretical concepts, you will be introduced to specific data management and spatial analysis techniques that have proved to be useful for analyzing, interpreting and visualizing cultural heritage data. Lectures will be alternated with practical exercises, where you will get hands-on experience in working with geodatabases, GIS, remote sensing and statistics. Finally, you will be asked to reflect on the applicability within your own work: in what way can your research profit from these approaches?

Lecture Contents:
The course will be taught in 8 lessons of 3 hours plus one extra session to discuss the outcomes.
Each 3 hr block will start with a lecture introducing the general concepts and providing one or more illustrations from cultural heritage projects. The second half of the block will consist of practical exercises.

The following topics will be addressed:
1. Theory of databases and database standards
2. Database analysis and reporting
3. GIS I (geodata and mapping)
4. GIS II (spatial analysis)
5. GIS III (spatial statistics)
6. Remote sensing
7. Terrain models
8. Advanced visualisation (storymapping, 3D visualisation)

In the final session, you will be asked to present a reflection on how geospatial approaches can be implemented in your own line of research.

Teaching Method:
Plenary lectures and practicals.

Bibliography:
Individual articles and other resources will be provided in advance of the course.

Final Exam:
The course will be evaluated through the practical assignments and the final presentation.

Prerequisites:
No previous knowledge of GIS is required. For the practicals, you will need a personal laptop, preferably running the Windows operating systems. You will also need a working version of MSAccess (included in Microsoft Office 365). Installation instructions for other software resources will be provided before the start of the course.

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
40 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. Fascist Italy as a Case Study
Michele Dantini
15 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
Francesco Freddolini
30 Hours

Learning Outcomes:
The students will be able to engage critically with transcultural artistic exchanges c. 1400-1800, and understand how Western artists and their public understood their identity, forged stereotypes, and developed notions of alterity in relation to global connections.

Abstract:
European Art and Transcultural Exchange, c. 1400-1800
This course will explore how Europe represented, invented, manipulated, and interacted with the global work in a period of intense and constantly growing transcultural interactions. How did transcultural exchanges, explorations, art market(s), travels, and diplomatic interactions influence artistic production, taste, and collecting? By focusing on the early modern period (roughly 15th -18th centuries), this course explores material and artistic exchanges across cultures and investigates case studies casting light on how encounters among diverse societies have shaped art and visual/material culture. After a preliminary methodological and historical introduction, the course will focus especially on three major Italian centers—Rome, Florence, and Venice—to explore their interactions with the global world, and investigate how entangled objects, complex ethnoscapes, and mobility help us problematize the production and spectatorship of art in relation to local and global contexts.

Lecture Contents:
Tentative schedule (subject to change):
Introduction
Early Renaissance Artistic Exchanges between East and West
Crossing Boundaries and Forging Stereotypes, I
Explorations, Discoveries, Stereotypes
Diplomatic Encounters between Europe and Asia
Religious Encounters and Tensions between Europe and Asia
Collecting Across Cultures, I: Exploring and Collecting
Collecting across Cultures, II: Objects from Islam and the East in European Collections
Florence and the Americas
Venice: Mercantile Exchanges and Cross-Cultural Conflicts
Rome: Global Interests and Religious Expansion

Teaching Method:
Lectures and class discussions based on shared readings.

Bibliography:
Kathleen Christian and Leah Clark, eds., European Art and the Wider World, 1350-1550 (Manchester: Manchester University Press, 2017)

Emma Barker, ed., Art, Commerce, and Colonialism, 1600-1800 (Manchester: Manchester University Press, 2017), chapters 1 and 2
Bronwen Wilson, The World in Venice: Print, the City, and Early Modern Identity (Toronto: University of Toronto Press, 2005)
Lia Markey, Imagining the Americas in Medici Florence (University Park, PA: Penn State University Press, 2016)
Christopher M.S. Johns, China and the Church. Chinoiserie in Global Context (Oakland: University of California Press, 2016)
Cécile Fromont, The Art of Conversion: Christian Visual Culture in the Kingdom of Kongo (Chapel Hill: University of Virginia Press, 2014)
Francesco Freddolini and Marco Musillo, eds., Art, Mobility, and Exchange in Early Modern Tuscany and Eurasia(Abindgdon and New York: Routledge, 2020)

Further useful bibliography:
Jerry Brotton, Renaissance Bazaar. From the Silk Road to Michelangelo (Oxford: Oxford University Press, 2002)
Deborah Howard. Venice and the East. The Impact of the Islamic World on Venetian Architecture 1100-1500 (New Haven and London: Yale University Press, 2000)
James Harper, ed., The Turk and Islam in the Western Eye, 1450-1750 (Burlington, VT: Ashgate 2011)
Stephanie Leitch, "Burgkmair's Peoples of Africa and India (1508) and the Origins of Ethnography in Print," The Art Bulletin 91, No. 2 (June 2009): 134-159
Amin Jaffer and Anna Jackson, eds., Encounters: The Meeting of Asia and Europe 1500-1800 (London: Victoria & Albert Museum, 2004)
Michael North, ed., Artistic and Cultural Exchanges between Europe and Asia, 1400-1900. Rethinking Markets, Workshops and Collections, (Burlington, VT: Ashgate, 2010)
Daniela Bleichmar and Peter C. Mancall, eds., Collecting across Cultures. Material Exchanges in the Early Modern Atlantic World (Philadelphia: University of Pennsylvania Press, 2011)

Final Exam:
At the end of the course, each student will deliver a presentation on a topic of their choice.

Prerequisites:
None

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Identification, Analysis and Control of Dynamical Systems
Alberto Bemporad
20 Hours

Learning Outcomes:
Getting familiar with analyzing, controlling, estimating, and identifying dynamical systems, with emphasis on linear dynamical systems in state-space form.

Abstract:
The course provides an introduction to dynamical systems, with emphasis on linear systems in state-space form. After introducing the basic concepts of stability, controllability and observability, the course covers the main techniques for the synthesis of stabilizing controllers (state-feedback controllers and linear quadratic regulators) and of state estimators (Luenberger observer and Kalman filter). The course also briefly covers data-driven approaches of parametric identification to obtain models of dynamical systems from a set of data.

Lecture Contents:
Introduction to dynamical systems. Linear systems in continuous time. Lagrange's formula and modal analysis. Stability of linear systems. Linearization. Stability of nonlinear systems. Discrete-time linear systems. Discrete-time linear systems: equilibria, stability, Z-transform, transfer function. Steady-state analysis and DC gain. Closed-loop control concept, PID control. Reachability analysis, state-feedback control, observability analysis. State estimator, dynamic compensator. Linear quadratic regulator. Kalman filtering, LQG control. System identification: identification of autoregressive models, recursive least squares for systems identification, model selection criteria.

Teaching Method:
Lecture slides and blackboard

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

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

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

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
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- 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
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- Academy of Sciences, 102(52): 18801-6
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- 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
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- American Economic Review, 97(5): 1639-66
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- Sutton J. (1997), "Gibrat's Legacy", Journal of Economic Literature, 35:40-59
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- 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

Introduction to Cognitive and Social Neurosciences
Pietro Pietrini, Emiliano Ricciardi
24 Hours

Learning Outcomes:
At the end of the course, naïve-to-neuroscience students are expected to have a general background knowledge of general topics of cognitive and social neurosciences, and to get introduced to the basic principles of brain functional techniques and their applicability for assessing neural bases of mental functions.

Abstract:
This course will provide a general overview of different topics in Cognitive and Social Neurosciences and their multidisciplinary and translational applications. The course is intended for those students that – outside the CCSN track – are interested in understanding how the comprehension of the neurobiological basis of perception, cognitive skills, behavior, motor responses and decision-making processes could be meaningful even for their research field. In the first part of the course, we will introduce to the modern methodologies to assess brain responses in the human living brain and familiarize with basic concepts in cognitive and social neuroscience. In the second part, we will review seminal findings that had a major impact on our knowledge of cognitive processes and social interactions, as well as more recent studies that took advantage of neuroimaging, electrophysiology and brain stimulation methods to shed new light on visual art and perception, decision-making and behaviors, economics and business, neuroengineering and robotics.

Lecture Contents:
- Introduction to cognitive neuroscience, interaction of neuroscience with other disciplines, historical perspective of neuroscience; introduction to neuroimaging: advantages and limitations; outline of brain physiology
  Outline of brain anatomy and functional organization, introduction to brain metabolism and implications for cognitive neuroscience and neuroimaging
- Introduction to brain imaging techniques and outline of main research and clinical applications
  Introduction to the neural correlates of selected topics of cognitive and social neurosciences, such as motor control, memory and attention, action understanding, emotion and social interaction, decision-making processes, applied with a multidisciplinary approach in behavioral sciences, economics, or aesthetic perception
- Introduction on wow to design a behavioral or neuroimaging study and an experimental protocol in cognitive and social neurosciences.

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 selected articles will be shared with the students.
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:
Brief presentation of selected scientific articles

Prerequisites:
None

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Introduction to Consciousness and Sleep
Lecturer: Giulio Bernardi
Hours: 20

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 Islamic Culture: Language, Religion, Challenges
Amos Bertolacci
15 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 Macroeconomics

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

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Introduction to Network Theory
Guido Caldarelli
10 Hours

Learning Outcomes:
Basic Knowledge of Graph Theory and main results in the application of the methodology to various cases of study

Abstract:
we shall provide a broad overview of the concepts and the methods constituting
modern network theory.

Lecture Contents:
LECTURE 01 Introduction
LECTURE 02 Graph Theory Introduction
LECTURE 03 Properties of Complex Networks I
LECTURE 04 Communities
LECTURE 05 Different kind of Graphs
LECTURE 06 Ranking
LECTURE 07 Static Models of Graphs
LECTURE 08 Dynamical Models of Graphs
LECTURE 09 Fitness Models
LECTURE 10 Financial Networks
AVAILABLE AT http://guidocaldarelli.com/index.php/lectures

Teaching Method:
Power point Lectures (DOWNLOAD AT http://guidocaldarelli.com/index.php/lectures)

Bibliography:
Scale-Free Networks G. Caldarelli
Networks, Crowds and Markets by David Easley and Jon Kleinberg

Final Exam:
essay/discussion with teacher

Prerequisites:
None

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Introduction to Neuro-Linguistics
Alessandra Rampinini
12 Hours

Learning Outcomes:
Acquiring basic concepts in General Linguistics that can be applied to Neuroscience and the study of language in the brain. Navigating the basic topics in the cognitive neurosciences of language, being able to evaluate and assess methodologies as well as results and theoretical issues related to the discipline.

Abstract:
Linguistics is a social science with a very special feature: it sits at the mind/brain interface. The brain governs our very own biochemistry, giving rise to the biological structures controlling our muscles, ears and breath in verbal languages, or our hands and eyes in the case of sign languages. The mind gives rise to the interpretation of language, as well as memory for meanings and uses, and our own intentions when using language to interact with our peers, knowing that they can understand us. In this course, we will go through these aspects in bird's eye view, studying how single languages came to be in the history of humankind, and how language as a general cognitive ability is controlled by different parts of the brain in a complex system of feedback and feedforward mechanisms.

Lecture Contents:
Introduction to language; functional and structural neuroanatomy of language-dedicated regions; language, handedness and hemispheric specialization; cognitive control in bilingualism; sign language introduction; introduction to language evolution and genetic aspects. Please note: this course is intended for students coming from different backgrounds and tries to be interesting to linguists as well as non-linguists: therefore, and due to time and logistics, some topics need to be overlooked or treated very quickly. The teacher is by all means available for further discussion or enquiries related to other topics if these lie within her own expertise.

Teaching Method:
frontal lesson with media and required interaction, guided discussions.

Bibliography:
Bibliographic suggestions will be given by the teacher in class.

Final Exam:
The final exam will be a closed-answer sheet and will be reserved to those having this class in their study plan. All auditors are welcomed to try it for personal assessment and without a a formal evaluation.

Prerequisites:
None

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Introduction to Neuropsychology
Francesca Garbarini
12 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
Rubber Hand Illusion
Written test + correction
Small group activities

Lesson 3 (3 hours):

Small group presentations
Pathological Embodiment
Written test + correction
Small group activities

Lesson 4 (3 hours):
Small group presentations
Somatoparaphrenia
Written test + correction
Small group activities

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

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

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 environmental economics.
Upon completion, participants will have the knowledge and skills to:
1. Have a basic understanding of the principles of environmental economics, including its fundamental principles and methods.
2. Have a basic understanding of the environmental problems and environmental policies.
3. Have a first knowledge of the current research topics, directions, and funding opportunities.
Participants will also be able to 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 Fundamental topics in the field of sustainability science and environmental economics.
The course is divided into the following modules:

1. **Introduction to sustainability science** (lectures 1-3)
2. **Basic principles of environmental and resource economics** (lectures 4-7)
3. **Methods** (lectures 8-9)
4. **Advanced topics** (lecture 10)

Within each module, specific case studies (e.g. related to climate policies, pollution, sustainable mobility) 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 the current cutting-edge research topics, stimulating their attention in the field. Participants will also be encouraged to formulate their research questions and to cooperate on new research papers.
The objective is 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	Basic principles of sustainability
Lecture 2	Environment and ethics
Lecture 3	Cost-benefit thinking
Lecture 4	Main concepts of environmental economics 1

Lecture 5	Main concepts of environmental economics 2
Lecture 6	Basic concepts of resource management
Lecture 7	Introduction to environmental policies
Lecture 8	Sustainable urban development (energy, mobility, waste)
Lecture 9	Principles of circular Economy
Lecture 10	Current research topics and trends

Teaching Method:
Lecture-cum-Demonstration

Bibliography:
R.K Turner, D. Pearce, I. Bateman, Environmental Economics: an elementary introduction, John Hopkins Univ. Press, 1994.
T. Tietenberg, L. Lewis. Environmental and Natural Resource Economics, Pearson Education, 2012.
I. Musu, Introduzione all'economia dell'ambiente. Il Mulino, 2020.

Final Exam:
No final exam

Prerequisites:
No prerequisites. The course is understandable by a broad audience. Technical and economic aspects will be treated in a gentle and introductory way

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Machine Learning
Giorgio Gnecco
20 Hours

Learning Outcomes:
At the end of the course, the student will have a basic knowledge of a quite large set of commonly used machine learning techniques.

Abstract:
The course provides an introduction to basic concepts in machine learning. Topics include: learning theory (bias/variance tradeoff, Vapnik-Chervonenkis dimension and Rademacher complexity, cross-validation); supervised learning (linear regression, logistic regression, support vector machines); unsupervised learning (clustering, principal and independent component analysis); semisupervised learning (Laplacian support vector machines); online learning (perceptron algorithm); hidden Markov models.

Lecture Contents:
- Lecture 1: Introduction to supervised learning and regression.
- Lecture 2: Classification problems.
- Lecture 3: Online learning: the perceptron learning algorithm and the LQG online learning framework.
- Lecture 4: Unsupervised learning.
- Lecture 5: Introduction to statistical learning theory.
- Lecture 6: Structural risk minimization and support vector machines.
- Lecture7: A joint application of econometrics and machine learning: trade-off between sample size and precision of supervision.
- Lecture 8: A comparison of approximation error bounds for neural networks and linear approximators.
- Lecture 9: Application of neural networks to optimal control problems.
- Lecture 10: Connection between supervised learning and reinforcement learning.

Teaching Method:
The teacher will project slides on the screen.

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

C. J. C. Burges, "A Tutorial on Support Vector Machines for Pattern Recognition," Data Mining and Knowledge Discovery, vol. 2, pp. 121-167, 1998

S. Mendelson, "A Few Notes on Statistical Learning Theory," in S. Mendelson, A. J. Smola (Eds.):

Advanced Lectures on Machine Learning, Lectures Notes in Artificial Intelligence, vol. 2600, pp. 1-40, Springer, 2003

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

J. Shawe-Taylor and N. Cristianini, "Kernel Methods for Pattern Analysis," Cambridge University Press, New York, USA, 2004

R. S. Sutton and A. G. Barto, "Reinforcement Learning: An Introduction," MIT Press, Cambridge, USA, 1998

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

S. Theodoridis and K. Koutroumbas, "Pattern Recognition," Academic Press, San Diego, USA, 2009

V. N. Vapnik, "Statistical Learning Theory," Wiley-Interscience, New York, USA, 1998

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 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. 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

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

Learning Outcomes:
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
(Sant'Anna School for Advanced Studies - Pisa)
Irene Crimaldi
12 Hours

Learning Outcomes:
By the end of this course, students will:
- be familiar with Markov processes in discrete and 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 of various types.

Abstract:
This course covers the fundamental results regarding Markov processes. 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, stationarydistribution, ergodic limit theorem, random walk and Gambler's ruin problem);
- Poisson process (definition, properties and applications);
- Markov processes with continuous time (definitions, Markov property, generator, forward Kolmogorov equations, stationary probability distribution);
- Birth-Death processes and queues.

Teaching Method:
Frontal teaching

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:
None

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

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.

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

Modelling and Verification of Reactive Systems
Lecturer: Rocco De Nicola
Hours: 20

Learning Outcomes:
Students will learn how to approach the design and verification of systems consisting of many interacting components and to tackle one of the key scientific challenges in computer science, namely the design and development of computing that behave as expected, and do so reliably.

Abstract:
The aim of this course is to introduce models for the formal description of computing systems, with an emphasis on parallel and reactive systems, and the techniques for system verification and validation that accompany them. As an important component of the course, we shall introduce industrial-strength software tools for modelling and analyzing the behaviour of (real-time) reactive systems.

Lecture Contents:
Finite state automata, Kripke structures, Labelled transition systems
Operators for Modelling composition of concurrent systems as labelled transition systems. First part: sequentialization, nondeterministic composition, parallelism, abstraction, recursion.
Behavioural Equivalences for labeled transition systems. Strong and weak variants of trace, testing and bisimulation equivalences.
Alternative approaches to the semantics of Concurrent systems. ACP and Axiomatic Semantics. CSP and Denotational semantics.
A calculus of Communicating Systems (CCS) and its operational and Axiomatic Semantics.
Logics for Specifying properties of concurrent Systems. Hennessy Milner Logic (HML) and Bisimulation. HML with recursion and fixed-point theory.
Temporal and Modal Logics and Model Checking techniques

Teaching Method:
Blackboard and Slides

Bibliography:
Handouts with the slides, some introductory books and web resources with software tools

Final Exam:
Projects considering Specification and Verification of simple systems and presentation of the outcomes in the classroom.

Prerequisites:
None

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Models of Organization of Cultural Institutions
Paola Dubini
30 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
60 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 in detail the brain circuits involved in social decision making.

Lecture Contents:
Introduction and scope of Neuroeconomics; The tools of Neuroeconomics; How human and animal preferences are represented in the mammalian nervous systems; Risk, time preferences, social preferences, and emotion; fundamentals of reinforcement learning, value learning, and value representation; The Neural mechanisms for choice; 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:
Written exam containing open questions and 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
Lecturer: Emiliano Ricciardi, Davide Bottari
Hours: 48

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 behaviour 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 programmes 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. Handouts are also provided.

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

Philosophical and Ethical Themes in Neuroscience
Mirko Daniel Garasic
10 Hours

Learning Outcomes:
Speculating over the ethical and political acceptability of certain innovations in the light of classical philosophical questions will provide the groundworks for any further neuroethical investigation envisaged.

Abstract:
Since its formal establishment as a self-standing field, neuroethics has been divided into two subdefinitions: the neuroscience of ethics and the ethics of neuroscience. While the neuroscience of ethics aims at explaining the way our brain works in relation to moral judgement, the ethics of neuroscience is a further expansion of bioethics: a discipline that wants to assess the moral dilemmas specifically raised by recent biotechnological advancements. This introductory course will focus on neuroethics in this latter sense, underlining the impact that discoveries concerning our brain can, do or will have on our society. Speculating over the ethical and political acceptability of certain innovations in the light of classical philosophical questions (i.e. What is justice? What constitutes a good life?) and other key terms necessary to understand the current debate (i.e. authenticity and personal identity, autonomy, responsibility and competence) will provide the groundworks for any further neuroethical investigation envisaged.

Lecture Contents:
Neuroethical Issues

Teaching Method:
Lectures and seminars

Bibliography:
Subject to change.

- Changeux, J. (2013). Neuroscience & Philosophy : An Exchange. The New York Review of Books.
- Farah, M. J. (2005). Neuroethics: the practical and the philosophical. Trends in Cognitive Sciences, 9(1), 34–40.
- McGinn, C. (2013). What Can Your Neurons Tell You?. The New York Review of Books.
- Open your mind. (2002). The Economist.
- Earp, B. D., Sandberg, A., & Savulescu, J. (2015). The Medicalization of Love. Cambridge Quarterly of Healthcare Ethics, 24(3), 323–336.
- Earp, B. D., Wudarczyk, O. a, Sandberg, A., & Savulescu, J. (2013). If I could just stop loving you: anti-love biotechnology and the ethics of a chemical breakup. The American Journal of Bioethics : AJOB, 13(11), 3–17.
- Gupta, K. (2012). Protecting Sexual Diversity: Rethinking the Use of Neurotechnological Interventions to Alter Sexuality. AJOB Neuroscience, 3(3), 24–28.
- Hauskeller, M. (2015). Clipping the Angel's Wings. Cambridge Quarterly of Healthcare Ethics, 24(3),

361–365.
- Earp, B. D., Sandberg, A., & Savulescu, J. (2014). Brave New Love: The Threat of High-Tech "Conversion" Therapy and the Bio-Oppression of Sexual Minorities. AJOB Neuroscience, 5(1), 4–12.
- Garasic, M. D. (2013). Anti-love biotechnology: was it not better to have loved and lost than never to have loved at all? The American Journal of Bioethics : AJOB, 13(11), 22–3.
- Savulescu, J., & Sandberg, A. (2008). Neuroenhancement of Love and Marriage: The Chemicals Between Us. Neuroethics, 1(1), 31–44.
- Schirmann, F. (2013). Badness, madness and the brain – the late 19th century controversy on immoral persons and their malfunctioning brains. History of the Human Sciences, 26(2), 33–50.
- Vincent, N. A. (2010). On the Relevance of Neuroscience to Criminal Responsibility. Criminal Law and Philosophy, 4(1), 77–98.
- Feresin, E. (2009). Lighter sentence for murderer with "bad genes." Nature.
- Garasic, M. D. (2013). The Singleton case: Enforcing medical treatment to put a person to death. Medicine, Health Care and Philosophy, 16(4), 795–806.
- Erler, A. (2011). Does Memory Modification Threaten Our Authenticity? Neuroethics, 4(3), 235–249.
- Mehlman, M. J. (2004). Cognition-Enhancing Drugs. Milbank Quarterly, 82(3), 483–506.
- Ricciardi, E., Rota, G., Sani, L., Gentili, C., Gaglianese, A., Guazzelli, M., & Pietrini, P. (2013). How the brain heals emotional wounds: the functional neuroanatomy of forgiveness. Frontiers in Human Neuroscience, 7, 839.
- Tennison, M. N., & Moreno, J. D. (2012). Neuroscience, Ethics, and National Security: The State of the Art. PLoS Biology, 10(3), e1001289.
- Lavazza, A., & Garasic, M. D. (2017). How Non-invasive Brain Stimulation Might Invade Our Sphere of Justice. Journal of Cognitive Enhancement, 1–8.
- Memories could be erased to cure soldiers of PTSD, say scientists. (2017). The Telegraph.

Final Exam:
No

Prerequisites:
None

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Philosophy and Neuroscience in Moral Reasoning
Gustavo Cevolani
12 Hours

Learning Outcomes:
On completing the course, the students will be able to appreciate the main issues surrounding the cognitive 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, cognition 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 them, how to justify these choices – is a classical problem of moral philosophy (ethics). More recently, moral psychologists started tackling those problems using a descriptive, empirically based approach. Still more recently, "neuroethicists" began investigating the neural correlates of moral judgment and the implications of neuroscientific results for moral philosophy. The course is an introduction to the essential issues arising at the interface between neuroscience, moral psychology, and moral philosophy. We shall explore problems concerning the biological and neural bases of moral thinking, the role of emotions in moral reasoning, 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.

Lecture 1. Presentation, discussion and choice of specific topics. Philosophical theories of moral reasoning. Consequentialism, deontology, and virtue ethics
Lecture 2. Dual-process theories of reasoning and cognition. Empirical approaches to morality.
Lecture 3. Moral dilemmas. Moral psychology and the neuroscience of ethics.
Lecture 4. Evolutionary approaches. Hume's problem. Reductionism and the debunking of morality.
Lecture 5. Objectivity, reason, and facts in moral reasoning. Machine ethics.
Lecture 6. Recap, verification and general discussion.

Teaching Method:
Mixture of lectures and discussion seminar.

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

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, 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 be better able to understand and evaluate 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 endeavors. 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.

Lecture 1. Presentation of the course. Discussion and choice of specific topics. What is science?
Lecture 2. How many sciences? The method(s) of science. Exact and inexact sciences.
Lecture 3. Theories, models, data. Experiments and observations.
Lecture 4. Inferences in science. Falsification, confirmation, disconfirmation.
Lecture 5. Science, pseudoscience, junk science. Trust and objectivity in science. The role of experts.
Lecture 6. History of science and scientific progress. The aim(s) of science.
Lecture 7. Science, truth, and reality.
Lecture 8. Recap, verification and general discussion.

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.

- Curd, Martin and J. A. Cover, eds. (1998). Philosophy of science: the central issues. New York: W.W. Norton.

- Godfrey-Smith, Peter (2003). Theory and Reality: An Introduction to the Philosophy of Science. University of Chicago Press.
- 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.
- Hempel, C. G. (1966). Philosophy of Natural Science. Prentice Hall.
- Popper, Karl (1963). Conjectures and Refutations: The Growth of Scientific Knowledge. Routledge.
- Salmon, Wesley C. (2017). The Foundations of Scientific Inference. Pittsburgh, Pa: University of Pittsburgh Press.
- Sprenger, Jan and S. Hartmann (2019). Bayesian Philosophy of Science. OUP Oxford.

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

Prerequisites:
None

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Political Economy
Alessandro Belmonte
20 Hours

Learning Outcomes:
Students will learn the principal methods and some major empirical applications of modern political economy, including how to apply games to political economic situations and how to apply empirical methods to test political economy theories

Abstract:
The course is a relatively advanced (i.e. at the beginning graduate level) but essentially self-contained introduction to the methods and some major applications of modern political economy.

Lecture Contents:
Topics:
- Institutions and "exogenous" differences in institutions
- At the origin of institutions: From Social Choice to Political Economics
- Median voter models and redistributive politics
- Probabilistic voting models
- Agency models of politics: Electoral accountability and career concerns
- Endogenous Institutions: Institutional transitions and conflicts.

Teaching Method:
Direct instruction complemented by active participation of students. Students will also be asked to present and discuss some relevant empirical works

Bibliography:
Textbooks:
1) Torsten Persson and Guido Tabellini (2000). Political economics: explaining economic policy. The MIT press.
2) Daron Acemoglu, Political Economy Lecture Notes.

Additional Readings:
1) Daron Acemoglu, Simon Johnson, James A. Robinson, The Colonial Origins of Comparative Development: An Empirical Investigation, AER 2001
2) James Feyrer and Bruce Sacerdote, Colonialism and Modern Income: Islands as Natural Experiments, RESTAT 2009
3) Toke S. Aidt, Raphaël Franck, Democratization Under the Threat of Revolution: Evidence From the Great Reform Act of 1832, ECMA 2015
4) Marianna Belloc, Francesco Drago and Roberto Galbiati, Earthquakes, Religion, and Transition to Self-Government in Italian Cities, QJE 2016
5) Sascha O. Becker and Luigi Pascali, Religion, Division of Labor and Conflict: Anti-Semitism in German Regions over 600 Years, AER 2019

6) Alesina Alberto and Fuchs-Schündeln Nicola, Goodbye Lenin (or Not?): The Effect of Communism on People's Preferences, AER 2007
7) Fernanda Brollo, Tommaso Nannicini, Roberto Perotti, and Guido Tabellini, The Political Resource Curse, AER 2013

Final Exam:
The exam develops in two parts: 1) students' presentation of an empirical article and 2) a summary of an article

Prerequisites:
The course assumes a good knowledge of macro and microeconomics (especially some growth theory, elementary taxation theory and game theory, including games with asymmetric/incomplete information and the theory of repeated games), of mathematical and statistical methods (especially static and dynamic optimization), and some introductory knowledge of econometric tools (especially familiarity with the issue of causality in econometrics and IV estimation), at the level of the relevant courses offered at IMT.

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

Principles of Concurrent and Distributed Programming
Rocco De Nicola, Letterio Galletta
30 Hours

Learning Outcomes:
A good understanding of the problems connected to concurrent programming and a good knowledge of the different approaches to modelling communication among distributed components and safe resource sharing. Students will also learn how to write simple concurrent programs.

Abstract:
The objective of the course is to introduce the basics of concurrent and distributed programming through an illustration of concepts and techniques related to modelling systems in which there are more components that are simultaneously active and need to coordinate and compete for the use of shared resources. By means of an hands-on approach, at the end of the course students will be able to write and evaluate concurrent programs using different programming languages.

Lecture Contents:
Basics of Computer Architectures. Concurrent Programming Styles: Iterative versus Recursive Parallelism Algorithms for guaranteeing mutual exclusion and implementing critical sections. Fair and unfair solutions.
Linguistic constructs for concurrent programming: Semaphores and Monitors.
Indirect Communication via Shared Memory and Direct Communication via Message Passing. Linguistic constructs for distributed programming: Rendez-Vous e Remote Procedure Calls.
Controlled Communication via shared tuple spaces and pattern matching. The coordination language LINDA.
Different approaches to model and program domain specific languages for network aware programming, service oriented computing, autonomic computing, collective adaptive systems.
How different programming languages deal with Concurrency, Parallelism, Mutual exclusion, Atomicity and Communication: Google Go language and Python, C++, C# and Erlang.
All the lectures about the above topics will be accompanied by practical lectures aiming at showing how the illustrated theory can be mapped on Java.

Teaching Method:
Blackboard; slides; programming exercises.

Bibliography:
Handouts with the slides, introductory books, research papers

Final Exam:
Programming Project and oral presentation

Prerequisites:
None

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Project Management
Beatrice Manzoni
35 Hours

Learning Outcomes:

- the course aims at: (1) Understanding the project management process, exploring the key concept of the discipline and acquiring the main logics and tools. (2) Practicing the principal project management techniques, applied to heritage and cultural industries' projects. (3) Managing a project team across the different phases of its life cycle. (4) Discussing the evolution of the research field in the discipline and the need for new research in relation to the developing practice and emerging trends.

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 organisations for strategy implementation, business transformation and new product development. Also, cultural industries are increasingly becoming project-based organisations.
Project success relies on the ability to deal with both technical and organisational 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 organisations?
- Getting started with some definitions: what is a project? What is the life cycle of a project? How do projects fit with processes in organisations? 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, managing and engaging people within the project context.

Teaching Method:
The course will take place online, with a mix of synchronous and asynchronous activities. Live classes will take place on Teams or Google Meet (tbc with the class). Please prepare all the pre-work before each class.

Bibliography:

Course materials are detailed in the schedule. For each session a set of slides will be distributed after class. Additional readings:

- PMI, A Guide to the Project Management Body of Knowledge (PMBoK Guide).
- IMA: Project Management Toolkit for Museums, 2017.
- Chapters 6, 7, 8 of Managing Art Projects with Societal Impact. 2016.

Final Exam:

Individual assignment (submission deadline by email: July 30, 2021). Detailed instructions will be presented in class.

Prerequisites:

None

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Qualitative and Quantitative Formal Methods for Computer Science
Rocco De Nicola, Mirco Tribastone
20 Hours

Learning Outcomes:
Students will learn the basic notions necessary for modelling and specifying computer systems using formal methods.

Abstract:
The course will be structured in two parts, one concentrating on the qualitative aspects of formal methods, the other on the quantitative one. Overall the course offers an introduction to core topics in formal methods for the functional specification and analysis of systems. Students will be exposed to basic models of computation and formal approaches to specifying the semantics of programming languages such as operational and denotational semantics. Moreover, they will learn about models for quantitative Analysis such as Markov chains and other stochastic models.

Lecture Contents:
Basic elements of discrete mathematics. Syntax of Programming Languages and different approaches to their Semantics. Labelled transition Systems, Inference Systems and Induction Principles.
Regular Expressions as a first programming language and their Denotational, Operational and Axiomatic Semantics.
Operational and Denotational Semantics of simple programming languages and their correspondence. Domain theory and fixed points. Total and Partial Functions. Complete Partial Orders, Continuity, Tarski theorem.
Basics of probability theory. Discrete and continuous-time Markov chains. Introductions to queuing networks.

Teaching Method:
Slides and blackboard

Bibliography:
Handouts with the slides and some introductory books. Research papers distributed throughout the course.

Final Exam:
Take home exam and students presentation

Prerequisites:
None

Research Seminars
Pietro Pietrini, Emiliano Ricciardi
30 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
Gabriele Costa
30 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 (12.04.21, 2 – 4 p.m.): Social networks: basic concepts; embeddedness, reflection problem; strong and weak ties (EK, chapters 2, 3)
- Slot 2 (14.04.21, 11 a.m. – 1 p.m.): Homophily, preferential attachment, and balance (EK, chapters 4, 5, 18)
- Slot 3 (15.04.21, 2 – 4 p.m.): Small world, cascading behavior and information cascades (EK, chapters 16, 19, 20)

Section II: Socio-economic networks: Individuals and Organizations
- Slot 4 (20.04.21, 4 - 6 p.m.): Influence and peer effects in social networks (readings 1-4)
- Slot 5 (21.04.21, 4 - 6 p.m.): Firms' collaborative agreements; networks of innovators (readings 5-8)

Section III: Empirics of Meso and Macro-Economic Networks
- Slot 6 (22.04.21, 4 - 6 p.m.): Trade networks and gravity (9-12)
- Slot 7 (27.04.21, 2 - 4 p.m.): Migration and human mobility (13-16)
- Slot 8 (28.04.21, 2 - 4 p.m.): Financial networks and systemic risk (17-19)
- Slot 9 (29.04.21, 2 - 4 p.m.): Production and knowledge networks (20-23)
- Slot 10 (04.05.21, 2-4 p.m.): Complexity and fitness (24-26)

Teaching Method:
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.

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

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

Software verification
Gabriele Costa, Letterio Galletta
Hours: 20

(Gabriele Costa - Hours: 10)

Learning Outcomes:
State-of-the-art methodologies for the formal verification of mobile software properties.

Abstract:
Formally verifying that a software complies with its specification is both crucial and difficult. Things are even worse when software developers are not trusted by the users. This happens usually in presence of mobile code. During this course we will consider the methodologies for the formal verification of software under the mobile code setting.

Lecture Contents:
Basics of mobile code compilation and distribution
Dynamic analysis techniques
Static analysis techniques
Symbolic execution and concolic testing

Teaching Method:
Theory + Practice with hands-on activity

Bibliography:
"The formal semantics of programming languages. An introduction" Glynn Winskel

Final Exam:
Project or seminar

Prerequisites:
None

(Letterio Galletta - Hours: 10)

Learning Outcomes:
At the end of the course, students will be able to formalise and prove correct static analyses, to implement simple analysers from scratch, and to use some state of the art static analysis tools.

Abstract:
Software is everywhere and it should behave as expected to avoid dramatic consequences. One of the

main reasons software misbehaves is that developers make errors when writing the source code. This course provides an overview of the main techniques for analysing source code and for checking its properties. The presented techniques include type-based, constraint-based analysis and abstract interpretation. The course will mix theory and practice: students will learn how to formalise analyses and prove them correct, will implement simple analysers from scratch, and also will experience state of the art static analysis tools

Lecture Contents:
Overview and preliminaries
Principles of static analysis techniques
Type analysis
Elements of Abstract Interpretation

Teaching Method:
Blackboard; slides.

Bibliography:
Slides and other material provided by the lecturer

Final Exam:
Individual project or presentation

Prerequisites:
None

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 process 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 of various types and be life-long learners who are able to independently expand their probabilistic and statistical expertise when needed.

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:
- Markov chains (definitions and basic properties, classification of states, invariant measure, stationary distribution, ergodic limit theorem, cyclic classes, passage problems);
- conditional expectation and conditional variance;
- martingales (definitions and basic properties, Burkholder transform, stopping theorem and some applications, predictable compensator and Doob decomposition, some convergence results, game theory, random walks, urn models);
- 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

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)
- W. Woess, Denumerable Markov chains, EMS textbooks in Mathematics (2009).

- 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 mathematical statistics

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

Temporary Organizing and Event Management in Cultural and Creative Industries
Yesim Tonga Uriarte
10 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:

- Bakker, R. M., DeFillippi, R. J., Schwab, A., & Sydow, J. (2016). Temporary organizing: Promises, processes, problems. Organization Studies, 37(12), 1703-1719.
- 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.
- Tonga Uriarte, Y., Antognozzi, T., Catoni, M. L. (2019). Investigating Tourism Impacts of Festivals: An exploratory case study of a big scale comic-con. Event Management, 23.
- Tsoukas H., Chia R. (2002). On organizational becoming: Rethinking organizational change. Organization Science, 13(5), 567–582.

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