National PhD in Artificial Intelligence – Health and Life Sciences area
Training activities - year 2026

	Title	Number of hours	Institution	Location	Attendance mode	Lecturer(s)	Academic year(s)	Semester	Timetable	Abstract
1	Mathematics, Deep Learning and Deep Reinforcement Learning	30	Università di Chieti-Pescara	Dipartimento di matematica, Firenze	Ibrido	Maurizio Parton	2023/2024, 2024/2025, 2025/2026	2	Lectures are available offline, with a set of videos made available by the lecturer. The lecturer is available to reply to questions of the students, and to set up the final examination.	The last few years have seen impressive accomplishments of artificial intelligence. Without a doubt, Deep Learning DL and Deep Reinforcement Learning DRL are the techniques that contributed most to these successes. Despite the extremely diverse areas involved (image recognition, games, biology, natural language processing, to name a few), we are still a long way from truly understanding the mathematics behind DL and DRL. Along with its theoretical interest, this would further increase their performance and fields of application. This course is addressed to mathematicians who aim to understand the relationship between DL/DRL and mathematics, in both directions. How can mathematicians contribute to the mathematical foundations of DL/DRL? How can DL/DRL be used by mathematicians in their everyday research field? After introducing DRL and DL in the first part of the course, we will provide (very partial) answers to the above questions by introducing some of the recent topics that in my opinion enlight this beautiful link between DL/DRL and mathematics, see bibliography. I will do my best to make this course accessible to the average mathematician. In particular, 2/3 of the course will be devoted to fundamentals of DRL and DL, so that no prior knowledge of DL or DRL is required. A basic knowledge in probability, algebraic geometry, differential geometry and/or Python could be helpful, but is not essential.
4	AI in Computer-aided drug design	15	SCITEC-CNR	Online	Online	Maria Cristina De Rosa, Davide Pirolli, Benedetta Righino	2025/2026	1	The course will be held in 2/3 weeks between March and July 2026; definitive dates will be delivered to enrolled students.	Drug discovery is an expensive and time-consuming process that is often assisted by computational methods to speed up and guide the design of new compounds. In the last decade, many studies have applied artificial intelligence in computer-aided drug design to obtain more accurate models and accelerate the design process. This course provides an overview of implementation of machine learning and deep learning algorithms in several drug discovery processes such as prediction of the target protein structure, structure-based and ligand-based drug design, evaluation of drug toxicity and physiochemical properties, quantitative structure–activity relationship. Specific case studies, related to applications of AI in drug development, will be discussed and used to ease the comprehension of the course arguments.
5	Multi-scale Applications of Mathematics to Medicine	15	UNIGE	online and in presence	online and in presence	Michele Piana, Anna Maria Massone, Sara Garbarino	2025/2026	2	First week of July, definitive dates will be delivered to enrolled students.	The course will discuss data simulation and processing methods for three biomedicine problems characterized by three different scales. At a cellular scale, we will describe a signalling network model for colon-rectal cancer and illustrates both formal and computational methods for its reduction. At a tissue scale, we will discuss parametric imaging approaches for the interpretation of nuclear medicine data. At an organ scale, we will describe some pattern recognition approaches for the extraction of radiomics features from both morphological and funcional images. The methodological topics will include inverse problems theory, dynamical systems, and artificial intelligence.
6	Behavioural biometrics for healthcare, security and related fields	15	Università degli studi di Bari Aldo Moro Campus Universitario	DIB Bari - online	online	Donato Impedovo, Vincenzo Dentamaro	2025/2026	2	April 14, h14-17; April 16, h09-12; April 17, h09-12; April 18, h09-12; April 30, h09-12	Behavioural biometrics for healthcare seek solutions to discover, classify, monitor, recognize diseases that are measurable only when the patient performs an action. This action could be walk, talk, write, type on the touchscreen and many more. Behavioral biometrics are, thus, interested in non directly measurable physical properties, but patterns that are recognized only when the patient performs a particular behavior. In general, it is the way the human being responses to natural events around him/her. In this course PhD students will learn shallow learning and deep learning techniques for recognizing pathological conditions using handwriting, gait analysis, speech analysis and many more.
10	Introduction to Neuromorphic Computing	12	Universita degli Studi di Roma Tor Vergata	online	online and in presence	Andrea Duggento	2021/2022, 2022/2023, 2023/2024, 2024/2025, 2025/2026	2	March 2026 - April 2026. The exact calendar is to be agreed upon. Students who wish to attend the course are invited to contact the lecturer by mid-February.	The mammalian brain is a very sophisticated, highly efficient biocomputer from which technology has begun to draw inspiration for developing artificial neural networks. However, this biology-to-technology translation is still in its infancy. Spiking neural networks based on neuromorphic architectures are emerging as a more biologically-inspired artificial minds which will likely underlie next-generation AI paradigms. This course will explore the biological – in silico correspondence at all levels, introducing key concepts of neuronal membrane potential dynamics, neuroanatomy and chemical neuromodulation, neural tissue energy demands, theory of evolution and principles of cognition. For each topic, its state-of-the-art neuromorphic engineering application counterpart will be presented. All major aspects of spiking neural network applications will be introduced, from training strategies (including principles of reinforcement learning, synaptic plasticity and multi-agent evolutionary artificial neural networks) to software and hardware implementation, e.g. including CMOS neuromorphic chips and memristor-based neuromorphic computers.
11	AI in medical image analysis	40	Istituto Nazionale di Fisica Nucleare	Sapienza Università di Roma and online	online and in presence	S. Giagu, A. Lonardo, F. Giove, A. Retico, et al.	2022/2023, 2023/2024, 2024/2025, 2025/2026	2	Students who wish to attend the course are invited to contact the lecturer by mid-February. The final calendar of the lectures will be communicated to interested students.	Medical digital images (Computed Tomography, Magnetic Resonance Imaging. etc.) play a key role in personalized therapy management, and are used in the diagnosis, treatment planning and monitoring of the disease and AI-driven solutions are emerging world-wide as a support in the clinical decision process. Deep Neural Networks, especially Convolutional Neural Networks, have opened up new avenues with the possibility of increasing accuracy in the detection and characterization of tumor tissues. Radiomic analysis, i.e. the extraction of a large number of quantitative features from the images and their combination through machine learning algorithms, is promising in several tasks, like predicting patient response to treatments. Students will acquire skills in modelling problems in medical image analysis, through AI based techniques, and be able to practically apply the learned techniques in some common use cases. Explainability techniques of the algorithms, as well as key concepts related to hardware and software architectures of modern computing devices will also be part of the course.
12	Modeling and managing medical processes	18	Università del Piemonte Orientale	Università del Piemonte Orientale	online and in presence	Alessio Bottrighi, Giorgio Leonardi, Stefania Montani, Luca Piovesan, Manuel Striani, Paolo Terenziani	2023/2024, 2024/2025, 2025/2026	2	April, 30 2026, h14-17 - May, 7 2026, h14-17 - May, 14 2026, h14-17 - May, 21 2026, h14-17 - May, 28 2026, h14-17 - June, 4 2026, h14-17. Students who wish to attend the course are invited to contact the lecturer to enroll in the course.	The course will focus on medical processes, with specific emphasis on their representation and their management. Different representation models will be considered, for clinical guidelines, clinical trials, and medical workflows, as well as the main aspects concerning acquisition and\or mining, representation, and use (e.g., simulation, decision support). Finally, the case of the treatment of comorbid patients will be considered, as a prototype of complex context in which multiple models have to be reconciled.
13	Neural Models and Algorithms for Linguistic Recognition and Inference	12	Università degli Studi di Roma, Tor Vergata	Università degli Studi di Roma, Tor Vergata	online and in presence	Roberto Basili, Fabio Massimo Zanzotto	2023/2024, 2024-2025, 2025/2026	1	In February 2026, final dates to be defined	Modern AI is growingly faced with complex problems, characterized by heterogeneous forms of structured evidences in input and complex decisions. In medicine historical data, biological phenomena or images manifest through streams of structured data, usually digitally represented into sequences, trees or graphs. Machine Learning methods for structured learning have been studied whereas some mathematical paradigms (such as dimensionality reduction, structured kernels or neural embedding) have been proposed as modelling tools. In Natural Language Processing, Machine Translation and other Natural Language Inference (NLI) tasks, such as Question Answering or Textual Entailment, have been approached via kernels or neural models of the input representation. These achieved accurate state-of-the-art classification and prediction capabilities by enabling the exploration of huge spaces of possible solutions (e.g. target sequences or decisions). In this way, they correspond to both enabling technologies and software tools as well as to models of investigation able to systematically select hypothesis and validate controversial theories about linguistic phenomena. The application of these empirical methodologies to other areas like biology, medicine and medical robotics is more than promising, given the similar complexity of the domains targeted by AI and Life Sciences. The course will try promote this interesting research perspective in Deep Learning to PhD students with a specific focus, but not limited to, Life Science phenomena.
17	Assessing the understandability of AI solutions in psychiatry	30	Universita' degli Studi di Bari Aldo Moro	Dipartimento di Biomedicina Traslazionale e Neuroscienze (DiBraiN), Bari.	Online and in presence	Cristina Berchio	2025/2026	2 semester	Days of Classes: -9/01/2026, h : 9-13; -16/01/2026, h : 14-18; - 23/01/2026, h : 9-13 ; - 30/01/2026, h : 9-13; - 2/02/2026, h : 9-13; - 6/02/2026, h : 9-13; - 9/02/2026, h : 9-13; - 13/02/2026, h : 9-11. Place: Dipartimento di Informatica, Campus Universitario, Bari.	This course aims to assess the understandability of artificial intelligence (AI) solutions in Psychiatry by investigating whether embedding clinical, neuroimaging, and pathophysiological information into AI models reduces uncertainty and generates more clinically relevant decisions. Psychiatric disorders show highly variable characteristics and risk factors. Therefore, AI prognostic and diagnostic solutions are fed with a wide variety of patient-related information (e.g., symptoms, behaviors, brain-related data). Because different diagnostic categories are often associated with drastically different clinical manifestations and neurobiological substrates, explaining clinical phenomena with AI is challenging. We will address this challenge by presenting algorithms that discriminate between psychiatric diagnoses based on multimodal data informed by biological and clinical priors. We will show AI solutions that are interpretable in clinical settings, besides generating a more comprehensive view of the pathophysiology of psychiatric conditions.

18	Law and Medicine	25	Università Campus Bio-Medico di Roma and IFSC and GNOSIS RESEARCH INSTITUTE	Online	Online	Stefano Regondi	2023/2024, 2024/2025, 2025/2026	2 semester	Thursday 05/03/2026 h 11.00-13.00 Online Thursday 12/03/2026 h 11.00-13.00 Online Thursday 19/03/2026 h 11.00-13.00 Online Thursday 26/03/2026 h 11.00-13.00 Online Thursday 02/04/2026 h 11.00-13.00 Online Thursday 09/04/2026 h 11.00-13.00 Online Thursday 16/04/2026 h 11.00-13.00 Online Thursday 23/04/2026 h 11.00-13.00 Online Thursday 30/04/2026 h 11.00-13.00 Online Wednesday 07/05/2026 h 11.00-13.00 Online Wednesday 14/05/2026 h 11.00-13.00 Online Wednesday 21/05/2026 h 10.00-13.00 Final exam (online or Dr. Regondi is available at IFSC Rome) Students who wish to attend the course are invited to contact the lecturer to enroll in the course.	In an era where Medicine and Technology rapidly evolve, the interplay between law and these domains becomes increasingly significant. This course offers a comprehensive exploration of the legal, ethical, and policy issues at the intersection of law, science, and technology. The curriculum focuses on how legal frameworks adapt to and shape advancements in several scientific fields, particularly artificial intelligence and robotics. This course aims to equip students with a profound understanding of the legal challenges posed by scientific and technological advancements.
20	Big Data in Healthcare	25	Università Campus Bio-Medico di Roma/Università Campus Bio-Medico di Roma	Università degli Studi di Messina	online	Antonio Celesti	2024/2025, 2025/2026	2	**2nd Semester academic year 2025-2026** -Tuesday, June 9th, 2026 h. 14:00-17:00 -Thursday, June 11th, 2026 h. 11:00-13:00 -Tuesday, June 16th, 2026 h. 14:00-17:00 -Thursday, June 18th, 2026 h. 11:00-13:00 -Tuesday, June 23th, 2026 h. 14:00-17:00 -Thursday, June 25th, 2026 h. 11:00-13:00 -Tuesday, June 30th, 2026 h. 14:00-17:00 -Thursday, July 2nd, 2026 h. 11:00-13:00 -Tuesday, July 7th, 2026 h. 14:00-17:00 -Thursday, July 9th, 2026 h. 11:00-13:00	The use of Big Data in biomedical and health sciences has received a lot of attention in recent years. These pieces of data present a significant opportunity for the improvement of the diagnosis, treatment and prevention of various diseases, and to interventions to improve health outcomes. The objective of the course is to provide the basic knowledges to understand, design, develop Big Data Systems. Moreover, particular attention will be given to methodologies and software tool for Big Data Storage, Warehousing and advanced Machine Learning based Analytics. In the end, case studies on the adoption of Big Data in healthcare will be discussed.
21	Knowledge Engineering	25	Univerità degli Studi della Campania Luigi Vanvitelli	Dipartimento di Ingegneria - Università della Campania (Aversa) and online	Phygital; part of the course will be held asynchronously, through a MOOC platform	Beniamino Di Martino, Luigi Colucci Cante, Mariangela Graziano	2024/2025, 2025/2026	2	From September to December 2026	The course introduces the topics and concepts of the field of Artificial Intelligence that deals with the Representation and Management of Knowledge, through methods and techniques based mainly on Logic and the production of rules. After an introduction, focused on the presentation of concrete examples of Intelligent Systems based on Rule-based techniques, we start with an overview of Problem-Solving techniques based on Research in State Spaces. The main models for the Representation of Knowledge are then introduced, with an in-depth study dedicated to the architecture and languages of the Semantic Web. We then move on to models and techniques of automated reasoning based on deduction and inference, in particular models based on Logic, with particular attention to the language of inference for the Semantic Web – SWRL. Finally, important fields of application of the methods illustrated are presented: Natural Language Processing, Process Mining and Semantic Web Services. Some of the lectures will be given in Italian.
23	Hands-on Machine Learning & Deep Learning	20	Università Campus Bio-Medico di Roma	Università Campus Bio-Medico di Roma/online	phygital	Valerio Guarrasi	2023/2024, 2024/2025, 2025/2026	2	March 2025	In this course, students will gain an inital understanding of Machine Learning and Deep Learning concepts. They will learn how to develop and implement various Machine Learning models using Python and acquire the skills to choose the appropriate models for different types of problems. Building intuition for these models and their practical uses is a key objective, along with mastering the skills for making accurate predictions and robust analyses.
25	Etica Personalista Applicata all'Intelligenza Artificiale	7	Università Campus Bio-Medico di Roma	Università Campus Bio-Medico di Roma		Vittoradolfo Tambone, Giampaolo Ghilardi, Nicola Di Stefano, Francesco De Micco	2024/2025	tbd	to be defined	Contenuti: Introduzione all'Etica Personalista, L'AI alla Luce del Personalismo, Principi Etici Personalisti Applicati all'uso della AI, Casi Studio Personalisti sull'AI in Life Science
26	Introduction to Multi-Omics Sciences with Bioinformatics and Artificial Intelligence	18	University of Siena	Online	Online	Fabrizio Celesti	2025/2026	2	Every Tuesday h. 08:30 - 10:30 and Thursday h. 08:30 - 11:30 from May 5th, 2026, to June 4th, 2026.	The course introduces the connection between bioinformatics and artificial intelligence (AI) within Multi-Omics Sciences, including genomics, transcriptomics, proteomics, and epigenomics. Its goal is to give students basic knowledge and practical skills to analyse large biological datasets using modern computational tools and basic AI-based methods. Main topics include an overview of essential biology concepts, different types of omics data and the technologies used to produce them. The course also covers basic statistical and computational methods for processing and combining these data. Central focus is given to biomarker discovery, precision medicine, and network-based Multi-Omics analysis. Students will also have basic experience with software tools and programming languages (e.g., R). By the end of the course, students will be able to design and run simple analysis workflows for Multi-Omics data, critically assess basic AI models used in biological research, and contribute to new applications in systems biology and personalised medicine. The course is suitable for students in biology, biotechnology, bioinformatics, computer science, or related fields who want to strengthen their skills in the growing area of bioinformatics and AI applied to Multi-Omics Sciences.
27	Network Science and Applications in Biology, Health Sciences, and Neuroscience	12	Università di Bari	online	Online	Nicola Pedreschi, Giulio Pergola	2025/2026	2	•Monday 11/05/2026, 11:00-13:00 •Thursday 14/05/2026, 11:00-13:00 •Monday 18/05/2026, 11:00-13:00 •Thursday 21/05/2026, 11:00-13:00 •Monday 25/05/2026, 11:00-13:00 •Thursday 28/05/2026, 11:00-13:00 •Thursday 11/06/2026, 10:00-13:00 (Final Exam)	This course integrates Network Science with a focus on its applications in biology, health sciences, and neuroscience. Participants will explore how complex biological systems, such as (among others) gene co-expression networks and neural networks, can be modeled through network theory. The course aims to equip students with the tools to analyze biological networks and apply network-based approaches to address multifaceted research challenges.
28	The AI Act and its operational interaction with the GDPR	10	Università Campus Bio-Medico di Roma	Università Campus Bio-Medico di Roma/GP4AI/Università di Bari	On Line	Dott. Avv. Claudio Caldarola, con seminari del Prof Antonio Felice Uricchio	2025/2026	2	- 19 ottobre 2026, ore 11:00–13:00 - 21 ottobre 2026, ore 11:00–13:00 - 26 ottobre 2026, ore 11:00–13:00 - 28 ottobre 2026, ore 11:00–13:00 - 3 novembre 2026, ore 11:00–13:00	The course provides a comprehensive introduction to the AI Act (EU Regulation 2024/1689), its classification of artificial intelligence systems based on risk levels, and the corresponding obligations for providers, developers, and users. Particular attention is dedicated to the interactions between the AI Act, the GDPR, and Italian legislation (Law 132/2025), with in-depth coverage of systemic risks, responsibilities, governance, data quality, Fundamental Rights Impact Assessments (FRIA), and Data Protection Impact Assessments (DPIA). The course also offers an overview of the first national regulations on AI in the healthcare sector, analyzing opportunities, constraints, and legal and ethical challenges. Through case studies and applied examples, students will acquire the skills needed to interpret, assess, and implement artificial intelligence solutions that comply with both the European and Italian regulatory frameworks.

29	Artificial Intelligence for Mental Health and Well-being	20	CNR – Institute for Biomedical Research and Innovation (IRIB), Messina	Online	Online	Flavia Marino	2025/2026	2	Thursday, May 7, 2026 h.9:00-12:00 Tuesday, May 12, 2026 h.9:00-12:00 Thursday, May 14, 2026-h. 9:00-12:00 Tuesday, May 19, 2026 - h. 9:00-12:00 Thursday, May 21, 2026- h. 9:00-12:00. Thursday, May 28, 2026 – 9:00 AM – 12:00 (final exam)	This course explores the use of Artificial Intelligence in the promotion of mental health and psychological well-being, analyzing digital tools and systems applied to assessment, prevention, and intervention in clinical, educational, and workplace settings. Topics include usability, acceptability, and ethical impact of AI-based technologies, with a focus on person-centered design and inclusion. Predictive models for early detection of psychological distress and use cases integrating AI, robotics, virtual reality, and telehealth will be discussed.
30	Docker is All You Need: Hands-On Containerization for Reproducible Research	10	Università Campus Bio-Medico di Roma	Università Campus Bio-Medico di Roma / (link Microsoft Teams)	Phygital	Ermanno Cordelli	2025/2026	1	February 2026: Tuesday 10 - 15:00 to 17:00 Friday 13 - 15:00 to 17:00 Tuesday 17 - 15:00 to 17:00 Friday 20 - 15:00 to 17:00 Tuesday 24 - 15:00 to 17:00	Research reproducibility remains a critical challenge in academia and enterprising application. Machine learning models that function on one system often fail on another due to dependency conflicts. Data pipelines break across operating systems because of path inconsistencies. Collaborators face prolonged setup times with environment-specific installations, while "it works on my machine" issues undermine collaboration and delay progress. Whether deploying AI frameworks like PyTorch, robotics frameworks such as ROS, or any computational workflow, these problems hinder scientific advancement across disciplines. Docker addresses these issues effectively. It packages Python applications, data processing scripts, robotics frameworks, and environments into portable containers that execute consistently across Windows, macOS, Linux, and external drives. Researchers can share immutable images through registries like Docker Hub and manage multi-service applications using Docker Compose for APIs, queues, databases, and sensor simulations. This approach enables reliable builds, streamlined workflows compatible with version control systems, and platform-independent deployment, converting fragile experiments into dependable, shareable research outputs.

In the case a course reports a time interval rathern than specific dates, Students are encouraged to contact the Lecturers as detailed in the specific course presentation

In general, Students have to contact in advance the Lecturers to enroll in the course

Title: Mathematics, Deep Learning and Deep Reinforcement Learning

Number of hours: 30

Institution(s): Università di Chieti-Pescara

Location(s): Dipartimento di matematica, Firenze

Type: Ph.D. course

Attendance Mode: Hybrid

Final Exam: Yes

Lecturer(s): Maurizio Parton

Responsible Expert(s)\email: Maurizio Parton, Università di Chieti-Pescara, maurizio.parton@unich.it

Academic Year: 2021/2022, 2022/2023, 2023/2024, 2024/2025

Semester: 2 (please consider that the course can be selected by the student in the first or in the second year of the PhD)

Timetable: January 2025, dates to be decided. Students who wish to attend the course are invited to contact the lecturer by the mid of July 2024. Specific dates will be communicated to interested students.

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

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

After introducing DRL and DL in the first part of the course, we will provide (very partial) answers to the above questions by introducing some of the recent topics that in my opinion enlight this beautiful link between DL/DRL and mathematics, see bibliography.

I will do my best to make this course accessible to the average mathematician. In particular, 2/3 of the course will be devoted to fundamentals of DRL and DL, so that no prior knowledge of DL or DRL is required. A basic knowledge in probability, algebraic geometry, differential geometry and/or Python could be helpful, but is not essential.

Learning Outcomes: At the end of the course the student should be able to communicate DRL and DL concepts with a proper and sound language, and to read and partially understand textbooks and research papers on the topics.

Detailed lecture contents:
-) Machine learning techniques that to date have proved useful in theoretical mathematics: reinforcement learning, and deep learning combined with explainability.
-) Theoretical mathematics techniques useful for machine learning: geometric deep learning.
-) Elements of Colab, Python, and Keras.
-) Details on AlphaGo Zero and MCTS.

Teaching method: Slides in English, **lectures in Italian**.

Final Exam: oral presentation of topics from the course, or presentation of a research paper, or project.

Prerequisites: none.

Key Bibliography:

-) Constructions in combinatorics via neural networks, https://arxiv.org/abs/2104.14516.
-) Geometric deep learning, https://arxiv.org/abs/1611.08097.
-) The Calabi-Yau Landscape, https://arxiv.org/abs/1812.02893.
-) Constructing and Machine Learning Calabi-Yau Five-folds, https://arxiv.org/abs/2310.15966.
-) Principles of Riemannian Geometry in Neural Networks, https://papers.nips.cc/paper/2017/hash/0ebcc77dc72360d0eb8e9504c78d38bd-Abstract.html.
-) Advancing mathematics by guiding human intuition with AI, https://www.nature.com/articles/s41586-021-04086-x.
-) Finding Increasingly Large Extremal Graphs with AlphaZero and Tabu Search , https://arxiv.org/abs/2311.03583.
-) https://www.youtube.com/watch?v=inN8seMm7UI. Video, Colab 3m introduction.
-) https://colab.research.google.com/. Colab introduction, notebook.
-) https://colab.research.google.com/github/cs231n/cs231n.github.io/blob/master/python-colab.ipynb. Python crash course, perfect if you want to get the idea of this language in less than 1h.

Title: AI in Computer-aided drug design

Number of hours: 15

Institution: Istituto di Scienze e Tecnologie Chimiche "Giulio Natta" (SCITEC)-CNR

Location: CNR p.le A. Moro, Roma and online

Type: Ph.D. course

Attendance Mode: Online and in presence

Final Exam: Yes

Lecturers: Maria Cristina De Rosa (SCITEC-CNR), Davide Pirolli (SCITEC-CNR), Benedetta Righino (SCITEC-CNR)

Responsible Expert\email: Maria Cristina De Rosa, mariacristina.derosa@cnr.it

Academic Year: 2025/2026

Semester: 2 semesters a.a. 2025/2026

Timetable: The course will be held between March and July 2026, definitive dates will be delivered to enrolled students. Students who wish to attend the course are invited to contact the lecturer by mid-February. Specific dates will be communicated to interested students.

Abstract: Drug discovery is an expensive and time-consuming process that is often assisted by computational methods to speed up and guide the design of new compounds. In the last decade, many studies have applied artificial intelligence in computer-aided drug design to obtain more accurate models and accelerate the design process. This course provides an overview of implementation of machine learning and deep learning algorithms in several drug discovery processes such as prediction of the target protein structure, structure-based and ligand-based drug design, evaluation of drug toxicity and physiochemical properties, quantitative structure–activity relationship. Specific case studies, related to applications of AI in drug development, will be discussed and used to ease the comprehension of the course arguments.

Learning Outcomes: The course is aimed to introduce basic concepts and to provide the basis of practical applications on the impact of Artificial Intelligence (AI) in computational chemistry. It will make participants familiar with a wide set of AI-driven computational approaches in the field of drug discovery and structural biology.

Detailed lecture contents:

1. Introduction on AI in drug discovery
2. AI in protein structure prediction
3. Augmenting virtual screening using AI
4. Accelerating lead identification
5. AI-based QSAR approaches
6. ADME/Tox prediction by AI

Teaching method: Powerpoint slides

Final Exam: Evaluations will be based on i) student's participation in discussion during the classes; and ii) brief presentation of selected scientific articles related to the course. Final exam will be held during regular class times

Prerequisites: None

Key Bibliography:

1. Fleming N. How artificial intelligence is changing drug discovery. Nature. 2018 May; 557(7707): S55-S57. doi: 10.1038/d41586-018-05267-x
2. Paul D. Artificial intelligence in drug discovery and development. Drug Discovery Today. 2021 January 26(1):80-93. doi: 10.1016/j.drudis.2020.10.010
3. Crampon K et al. Machine-learning methods for ligand–protein molecular docking. Drug Discovery Today. 2022 January; 27(1):151-164. doi: 10.1016/j.drudis.2021.09.007

UNIVERSITÀ CAMPUS BIO-MEDICO DI ROMA

Title: Multi-scale Applications of Mathematics to Medicine

Number of hours: 15

Institution(s): Università di Genova

Location(s): Dipartimento di Matematica, Università di Genova and online

Type: Ph.D. course

Attendance Mode: In presence and Online

Final Exam: Oral presentation of a project concerning the topics illustrated in the course

Lecturer(s): Michele Piana, Anna Maria Massone, Sara Garbarino

Responsible Expert(s)\email: name, affiliation and email(s): Michele Piana, Dipartimento di Matematica Università di Genova, piana@dima.unige.it

Academic Year: 2024/2025

Semester: II semester

Timetable: First week of July, definitive dates will be delivered to enrolled students.

Abstract:
The course will discuss data simulation and processing methods for three biomedicine problems characterized by three different scales. At a cellular scale, we will describe a signaling network model for colon-rectal cancer and illustrate both formal and computational methods for its reduction. At a tissue scale, we will discuss parametric imaging approaches for the interpretation of nuclear medicine data. At an organ scale, we will describe some pattern recognition approaches for the extraction of radiomics features from both morphological and functional images. The methodological topics will include inverse problems theory, dynamical systems, and artificial intelligence

Learning Outcomes: knowledge of the main aspects of computational data analysis for biomedical data at different scales

Detailed lecture contents:

Cells

- Construction of signaling networks in cancer cells
- Computation of the proteomic equilibrium
- Uniqueness and sensitivity issues

Tissues

- Aspects of tracer kinetics in nuclear medicine

- Parametric imaging in nuclear medicine

Organs

- Extraction of radiomics features (geometry-based methods)
- Unsupervised clustering of radiomics features

Teaching method: Frontal lectures (with slides)

Final Exam: Oral presentation of a project concerning the topics illustrated in the course

Prerequisites: Some mathematics (numerical analysis, mathematical analysis)

Key Bibliography: slides, handouts and some papers concerned with the topics

UNIVERSITÀ CAMPUS BIO-MEDICO DI ROMA

Title: Behavioural Biometric for healthcare, security and related fields

Number of hours: 15

Institution(s): Università degli studi di Bari "Aldo Moro", dipartimento di informatica

Location(s): online

Type: Ph.D. course

Attendance Mode: online

Final Exam: Yes

Lecturer(s): Donato Impedovo, Vincenzo Dentamaro

Responsible Expert(s)\email: Donato Impedovo, donato.impedovo@uniba.it

Academic Year: 2024/2025

Semester: 2

Timetable: April 14, h14-17; April 16, h09-12; April 17, h09-12; April 18, h09-12; April 30, h09-12 2025. Students who wish to attend the course are invited to contact the lecturer by mid-March. Specific dates will be communicated to interested students.

Abstract: Behavioural biometrics for healthcare seek solutions to discover, classify, monitor, recognize diseases that are measurable only when the patient performs an action. This action could be walk, talk, write, type on the touchscreen and many more. Behavioral biometrics are, thus, interested in non directly measurable physical properties, but patterns that are recognized only when the patient performs a particular behavior. In general, it is way the human being responses to natural events around him/her. In this course PhD students will learn shallow learning and deep learning techniques for recognizing pathological conditions using handwriting, gait analysis, speech analysis and many more.

Learning Outcomes: At the end of the course the student should be able to conduct their own studies on behavioural biometrics as well as read and reproduce papers making use of behavioural biometrics in healthcare, security and related fields.

Detailed lecture contents:

Lecture 1: Introduction to behavioural biometrics in healthcare and security
Lecture 2: Introduction to shallow learning and Deep Learning techniques
Lecture 3: Neurodegenerative disease assessment through handwriting
Lecture 4: Neurodegenerative disease assessment through gait analysis
Lecture 5: Covid and other diseases assessment through sound

Teaching method:
The Teacher will project slides and may present some scientific paper on the topic.

Final Exam:
The student will prepare slides for a short seminar (20-30 minutes) on a topic related to those discussed during the course. The topic of the seminar will be either proposed by the teacher or chosen by the student. The date of the seminar will be agreed between the student and the teacher.

Prerequisites:
None

Key Bibliography:

- Impedovo, D., & Pirlo, G. (2018). Dynamic handwriting analysis for the assessment of neurodegenerative diseases: a pattern recognition perspective. *IEEE reviews in biomedical engineering*, *12*, 209-220.
- De Stefano, C., Fontanella, F., Impedovo, D., Pirlo, G., & di Freca, A. S. (2019). Handwriting analysis to support neurodegenerative diseases diagnosis: A review. *Pattern Recognition Letters*, *121*, 37-45.
- Dentamaro, V., Impedovo, D., & Pirlo, G. (2021, January). An Analysis of Tasks and Features for Neuro-Degenerative Disease Assessment by Handwriting. In *International Conference on Pattern Recognition* (pp. 536-545). Springer, Cham.
- Dentamaro, V., Giglio, P., Impedovo, D., & Pirlo, G. (2021, September). Benchmarking of Shallow Learning and Deep Learning Techniques with Transfer Learning for Neurodegenerative Disease Assessment Through Handwriting. In *International Conference on Document Analysis and Recognition* (pp. 7-20). Springer, Cham.
- Dentamaro, V., Impedovo, D., & Pirlo, G. (2020). Gait analysis for early neurodegenerative diseases classification through the kinematic theory of rapid human movements. *IEEE Access*, *8*, 193966-193980.
- Cicirelli, G., Impedovo, D., Dentamaro, V., Marani, R., Pirlo, G., & D'Orazio, T. (2021). Human gait analysis in neurodegenerative diseases: a review. IEEE Journal of Biomedical and Health Informatics.
- Convertini, N., Dentamaro, V., Impedovo, D., & Pirlo, G. (2021). Sit-to-Stand Test for Neurodegenerative Diseases Video Classification. International Journal of Pattern Recognition and Artificial Intelligence, 35(12), 2160003.
- Dentamaro, V., Giglio, P., Impedovo, D., Moretti, L., & Pirlo, G. (2022). AUCO ResNet: an end-to-end network for Covid-19 pre-screening from cough and breath. *Pattern Recognition*, 108656. doi:10.1016/j.patcog.2022.108656

UNIVERSITA' CAMPUS BIO-MEDICO DI ROMA

Title: Introduction to Neuromorphic Computing

Number of hours: 12

Institution(s): University of Rome Tor Vergata

Location(s): Rome, University of Rome Tor Vergata, via Montpellier 1

Type: Ph.D. course

Attendance Mode: Online

Final Exam: Yes

Lecturer(s): Andrea Duggento

Responsible Expert(s)\email: Andrea Duggento <andrea.duggento@uniroma2.eu>

Academic Year: 2021/2022, 2022/2023, 2023/2024, 2024/2025, , 2025/2026

Semester: 2

Timetable:
March 2026 - April 2026. The exact calendar is to be agreed upon. Students who wish to attend the course are invited to contact the lecturer by mid-February.

Abstract: The mammalian brain is a very sophisticated, highly efficient biocomputer from which technology has begun to draw inspiration for developing artificial neural networks. However, this biology-to-technology translation is still in its infancy. Spiking neural networks based on neuromorphic architectures are emerging as a more biologically-inspired artificial minds which will likely underlie next-generation AI paradigms. This course will explore the biological – in silico correspondence at all levels, introducing key concepts of neuronal membrane potential dynamics, neuroanatomy and chemical neuromodulation, neural tissue energy demands, theory of evolution and principles of cognition. For each topic, its state-of-the-art neuromorphic engineering application counterpart will be presented. All major aspects of spiking neural network applications will be introduced, from training strategies (including principles of reinforcement learning, synaptic plasticity and multi-agent evolutionary artificial neural networks) to software and hardware implementation, e.g. including CMOS neuromorphic chips and memristor-based neuromorphic computers.

Learning Outcomes: At the end of the course the student is expected to have acquired:

- A basic knowledge of the biological mechanisms that inspired the neuromorphic engineering field.
- The ability to conceptualize biologically plausible mechanisms into a neuronal simulation with learning capabilities.

Detailed lecture contents:

Lecture 1: Introduction, membrane potential, synapses, and chemical neuromodulation
Lecture 2: Spiking neural network in silico: models and simulation environments
Lecture 3: Hard-wired spiking neural network: CMOS vs Memristors
Lecture 4: Synaptic plasticity, neuromodulation strategies and learning.
Lecture 5: Chemical-modulated reinforcement learning and evolution: from biology to engineering

Teaching method:
Lectures based on whiteboard for analytical and qualitative concepts, slides for illustrating applications.

Final Exam:
The student will prepare a seminar on a topic to be agreed upon

Prerequisites:
Key Machine Learning Concepts

Key Bibliography:

- Principles of Neural Science, Sixth Edition, by Eric R. Kandel et Al., 2021
- Neuromorphic Engineering; The Scientist's, Algorithm Designer's, and Computer Architect's Perspectives on Brain-Inspired Computing, by Elishai Ezra Tsur, 2021
- Neuroscience, by D Purves et Al., 2018
- Selected articled from scientific literature.

UNIVERSITÀ CAMPUS BIO-MEDICO DI ROMA

National PhD in Artificial Intelligence
Area of specialization: Health and Life Sciences

Title: AI in medical image analysis

Number of hours: please insert any multiple of 5 from 10: 40

Institution(s): INFN & Centro Fermi.

Location(s): Online.

Type: Ph.D. course.

Attendance Mode: online

Final Exam: yes

Lecturer(s): prof. S. Giagu (Sapienza & INFN Roma), dr. A. Lonardo (INFN Roma), dr. F. Giove (Centro Fermi), dr.ssa A. Retico (INFN Pisa), et al.

Responsible Expert(s)\email:
stefano.giagu@uniroma1.it.

Academic Year: 2025/2026

Semester: 2nd

Timetable: Students who wish to attend the course are invited to contact the lecturer by mid-February. The final calendar of the lectures will be communicated to interested students.

Abstract: Medical digital images (Computed Tomography, Magnetic Resonance Imaging. etc.) play a key role in personalized therapy management, and are used in the diagnosis, treatment planning and monitoring of the disease and AI-driven solutions are emerging world-wide as a support in the clinical decision process. Deep Neural Networks, especially Convolutional Neural Networks, have opened up new avenues with the possibility of increasing accuracy in the detection and characterization of tumor tissues. Radiomic analysis, i.e. the extraction of a large number of quantitative features from the images and their combination through machine learning algorithms, is promising in several tasks, like predicting patient response to treatments. Students will acquire skills in modelling problems in medical image analysis, through AI based techniques, and be able to practically apply the learned techniques in some common use cases. Explainability techniques of the algorithms, as well as key concepts related to hardware and software architectures of modern computing devices will also be part of the course.

Learning Outcomes: acquire skills in modelling problems in medical image analysis, through AI based techniques, and be able to practically apply the learned techniques in some common use-cases. Learn the fundamental elements of the hardware architecture (control, data-path, instruction parallelism, hierarchy of memories) and system software and understand the impact they have on the performance of AI applications, enabling the conscious optimization of their implementation.

Detailed lecture contents: medical image modalities (CT, Xrays, MRI, PET). Image pre-processing and image normalization**.** Radiomic pipeline: radiomic features computation, feature selection and reduction, radiomic signatures. Machine learning algorithms for classification. Deep learning-based tissue segmentation algorithms: CNN, GNNs, Transformers, VIT, MoE-GT. Data augmentation and knowledge transfer techniques. Explainability techniques for medical image applications. Introduction to computers: hardware organization, firmware and software, performance definition and measurement. Computer arithmetic: arithmetic and logical operations. Processor Architecture: functional units, registers, control unit, microprogramming; processing unit; pipelining, exceptions handling. Memory hierarchy: cache memory, virtual memory. Storage and I/O. Overview of multicore systems, multiprocessors and clusters: parallel processing, classification, examples of many-core computing architectures (GPU), dedicated architectures for AI.

Teaching method: about 60% of the course takes place with lectures supplemented by projections of slides in the classroom and/or electronically, designed to provide advanced knowledge of the course topics. The remaining 40% is based on hands-on computational practical experiences using google colab platform, that provide some of the application skills necessary to independently develop and implement AI pipelines for segmentation of medical images and for radiomic analysis.

Final Exam: discussion about a topic treated in the course chosen by the student + 1 topic chosen by the teacher.

Prerequisites: elements of python programming and elements of machine learning and neural networks.

Key Bibliography: given the highly dynamic nature of the topics covered in the course, there is no single reference text. During the course, the sources will be indicated and provided from time to time in the form of scientific and technical articles and book chapters.

UNIVERSITA' CAMPUS BIO-MEDICO DI ROMA

Title: Modelling and managing medical processes

Number of hours: 18

Institution(s): University of Eastern Piedmont

Location(s): Alessandria\Online

Type: Ph.D. course

Attendance Mode: In presence (Alessandria) + Online

Final Exam: Yes

Lecturer(s): Alessio Bottrighi, Giorgio Leonardi, Stefania Montani, Luca Piovesan, Manuel Striani, Paolo Terenziani

Responsible Expert(s)\email:
Alessio Bottrighi, University of Eastern Piedmont, alessio.bottrighi@uniupo.it
Giorgio Leonardi, University of Eastern Piedmont, giorgio.leonardi@uniupo.it
Stefania Montani, University of Eastern Piedmont, stefania.montani@uniupo.it
Luca Piovesan, University of Eastern Piedmont, luca.piovesan@uniupo.it
Manuel Striani, University of Eastern Piedmont, manuel.striani@uniupo.it
Paolo Terenziani, University of Eastern Piedmont, paolo.terenziani@uniupo.it

Academic Year: 2025/2026

Semester: 2

Timetable:
April, 30 2026, h14-17 - May, 7 2026, h14-17 - May, 14 2026, h14-17 - May, 21 2026, h14-17 - May, 28 2026, h14-17 - June, 4 2026, h14-17.
Students who wish to attend the course are invited to contact the lecturer to enroll in the course.

Abstract:
The course will focus on medical processes, with specific emphasis on their representation and their management. Different representation models will be considered, for clinical guidelines, clinical trials, and medical workflows, as well as the main aspects concerning acquisition and\or mining, representation, and use (e.g., simulation, decision support). Finally, the case of the treatment of comorbid patients will be considered, as a prototype of complex context in which multiple models have to be reconciled.

Learning Outcomes:
The students will acquire knowledge about the main types of models for medical processes, and of operational facilities to acquire, represent and use them. The course will provide basic background knowledge about such topics, as well as hints about most advanced research, and recent “hot topics”.

Detailed lecture contents:
Lesson 1. Introduction to clinical guidelines. Different representation methods. Guideline acquisition, representation and execution. Advanced decision support facilities.
Lesson 2. Introduction to comorbid patient problematics. Analysis of techniques and methodologies for safe and efficient reconciliation of multiple (medical) models.
Lesson 3. Introduction to data acquisition and management for clinical trials. Electronic Data Capture approaches and standards. AI approaches for the management of clinical trials.
Lesson 4. Introduction to workflow. Workflow perspectives (organisational, data-flow, control-flow) and relative workflow patterns. Brief introduction to Process Mining.
Lesson 5. From process traces to process models: process mining. The ProM tool. Uses of process mining. Improving process mining and process comparison through domain knowledge.
Lesson 6. Techniques and methodologies of NLP/LLMs applied to Process Mining to enhance the quality of healthcare processes.

Teaching method:
Lesson & slide online

Final Exam:
Student seminar about a topic agreed together with the teachers.

Prerequisites:
Basic knowledge about AI knowledge representation formalisms

Key Bibliography:

Robert A. Greenes, Clinical Decision Support: The Road to Broad Adoption, Academic Press; 2nd edition ISBN: 978-0-123-98476-0 (2014)

Wil van der Aalst, Process Mining: Data Science in Action, Springer, ISBN: 978-3-662-57041-8 (2016)

UNIVERSITA' CAMPUS BIO-MEDICO DI ROMA

Title: Neural Models and Algorithms for Linguistic Recognition and Inference

Number of hours: 12

Institution(s): University of Roma, Tor Vergata

Location(s): Online

Type: Ph.D. course

Attendance Mode: Phygital

Final Exam: Yes

Lecturer(s): Roberto BASILI, Fabio Massimo ZANZOTTO

Responsible Experts: basili@info.uniroma2.it, fabio.massimo.zanzotto@uniroma2.it

Academic Year: 2023/2024, 2024/2025, 2025/2026

Semester: 1

Timetable: In February 2026, final dates to be defined.
Students who wish to attend the course are invited to contact the lecturer to enroll in the course.

Abstract: Modern AI is growingly faced with complex problems, characterised by heterogeneous forms of structured evidence in input and complex decisions. In medicine historical data, biological phenomena or images manifest through streams of structured data, usually digitally represented into sequences, trees or graphs. Machine Learning methods for structured learning have been studied whereas some mathematical paradigms (such as dimensionality reduction, structured kernels or neural embedding) have been proposed as modelling tools. In Natural Language Processing, Machine Translation and other Natural Language Inference (NLI) tasks, such as Question Answering or Textual Entailment, have been approached via kernels or neural models of the input representation. These achieved accurate state-of-the-art classification and prediction capabilities by enabling the exploration of huge spaces of possible solutions (e.g. target sequences or decisions). In this way, they correspond to both enabling technologies and software tools as well as to models of investigation able to systematically select hypotheses and validate controversial theories about linguistic phenomena. The application of these empirical methodologies to other areas like biology, medicine and medical robotics is more than promising, given the similar complexity of the domains targeted by AI and Life Sciences. The course will try to promote this interesting research perspective in Deep Learning to PhD students with a specific focus, but not limited to, Life Science phenomena.

Learning Outcomes: Knowledge about the state-of-the-art neural inference methods through their applications to structured input (sequences, trees and graphs) for classification, transduction and

discovery tasks. The course will discuss fruitful integration of deep neural and kernel-based learning methods as modelling tools for complex structures.

Detailed lecture contents:

Lesson 1 (2+2 hours)**:** **Kernel Methods for Language Modeling (RB)**

Lesson 2 (2+2 hours): **Autoregressive Encoder-Decoders for Neural Natural Language Inference and Question Answering (RB)**

Lesson 3 (2+2 hours): **Neural Transducers for Biological sequences and for structures (FMZ)**

Teaching method: Presentation of mathematical and algorithmic contents via seminar-like teaching, and Lab exercises in Python to share experimental best practices about the main course topics.

Final Exam: Short Projects on specific datasets will be proposed to assess the acquired knowledge. A final presentation of the project results is expected to close the study.

Prerequisites: Basic knowledge of Machine Learning and Deep Learning methods, Basic knowledge on Natural Language Topics: Syntax and Semantics of Natural Languages, Text Classification and Textual Inference.

Key Bibliography:

- "On the properties of neural machine translation: Encoder-decoder approaches." Cho, Kyunghyun, et al. , *arXiv preprint arXiv:1409.1259* (2014).
- Deep Learning, Ian Goodfellow, Yoshua Bengio, Aaron Courville, MIT Press, 2016.
- Attention is all you need. Ashish Vaswani, Noam Shazeer, Niki Parmar, Jakob Uszkoreit, Llion Jones, Aidan N. Gomez, Łukasz Kaiser, and Illia Polosukhin. 2017. In Proceedings of the 31st International Conference on Neural Information Processing Systems (NIPS'17). Curran Associates Inc., Red Hook, NY, USA, 6000–6010.
- "BERT: Pre-training of Deep Bidirectional Transformers for Language Understanding", Jacob Devlin Ming-Wei Chang Kenton Lee Kristina Toutanova, Proceedings of NAACL-HLT 2019, pages 4171–4186, Minneapolis, Minnesota, June 2 - June 7, 2019.
- Making sense of kernel spaces in neural learning, D Croce, S Filice, R Basili, Computer Speech & Language 58, 51-75 (2019)
- Fabio Massimo Zanzotto, Andrea Santilli, Leonardo Ranaldi, Dario Onorati, Pierfrancesco Tommasino, and Francesca Fallucchi. 2020. KERMIT: Complementing Transformer Architectures with Encoders of Explicit Syntactic Interpretations. In Proceedings of the 2020 Conference on Empirical Methods in Natural Language Processing (EMNLP)
- Lorenzo Ferrone and Fabio Massimo Zanzotto, Symbolic, Distributed, and Distributional Representations for Natural Language Processing in the Era of Deep Learning: A Survey, Front. Robot. AI, 21 January 2020

UNIVERSITA' CAMPUS BIO-MEDICO DI ROMA

Title: Assessing the understandability of AI solutions in psychiatry

Number of hours: 30

Institution(s): Universita' degli Studi di Bari Aldo Moro

Location(s): Online and in presence

Type: Ph.D. course

Attendance Mode: Phygital

Final Exam: Yes

Lecturer(s): Dr. Cristina Berchio

Responsible Expert(s)\email: Cristina Berchio, Universita' degli Studi di Bari Aldo Moro, cristina.berchio@uniba.it

Academic Year: 2025-2026

Semester: 1/2

Timetable: January-February 2025. Course start date: 9 January 2025.
Students who wish to attend the course are invited to contact Dr. Berchio by January 9 th.

Days of Classes:
-9/01/2026, h : 9-13;
-16/01/2026, h : 14-18;
- 23/01/2026, h : 9-13 ;
- 30/01/2026 , h : 9-13;
- 2/02/2026, h : 9-13;
- 6/02/2026, h : 9-13;
- 9/02/2026, h : 9-13;
- 13/02/2026, h : 9-11.

Place: Dipartimento di Informatica, Campus Biomedico, Bari.

Abstract:
This course aims to assess the understandability of artificial intelligence (AI) solutions in Psychiatry by investigating whether embedding clinical, neuroimaging, and pathophysiological information into AI models reduces uncertainty and generates more clinically relevant decisions. Psychiatric disorders show highly variable characteristics and risk factors. Therefore, AI prognostic and diagnostic solutions are fed with a wide variety of patient-related information (e.g., symptoms, behaviors, brain-related data). Because

different diagnostic categories are often associated with drastically different clinical manifestations and neurobiological substrates, explaining clinical phenomena with AI is challenging. We will address this challenge by presenting algorithms that discriminate between psychiatric diagnoses based on multimodal data informed by biological and clinical priors. We will show AI solutions that are interpretable in clinical settings, besides generating a more comprehensive view of the pathophysiology of psychiatric conditions.

Learning Outcomes:
Students will gain knowledge and understanding about:
- Basic elements of AI in the field of psychiatry and neurobiological research;
- Applicability of AI models to brain-related data, with a specific focus on electrophysiology (EEG/MEG);
- Applicability of AI models to cognitive assessment, with a specific focus on psychiatric disorders.

Detailed lecture contents:
-Introduction to the basic concepts of AI in the context of cognitive assessment in psychiatry;
-Neurobiological bases of cognitive functions, cognitive and neurobiological deficits in the psychiatric context, using AI to understand and model cognitive functions, cognitive assessment tools;
- Discussion of research studies integrating AI in cognitive assessment;
-Ethical considerations in the use of AI in cognitive assessment, transparency and interpretability of AI models in cognitive assessment, impact of privacy and data security in AI-enhanced cognitive assessment;
-Use of AI in the diagnosis and treatment of psychiatric disorders, AI-based cognitive assessment in specific populations (e.g., children, at high-risk individuals), challenges and opportunities in applying AI to cognitive assessment;
-Limitations and challenges in implementing AI in cognitive assessment, discussion of cases and practical applications, new directions and research opportunities in applying AI to cognitive assessment.

Teaching method:
Lectures and exercitations.

Final Exam:
Students present the content of 1/2 papers suggested by the teacher. Final exam will be held during regular class times.

Prerequisites:
None.

Key Bibliography:
Scientific articles concerned with the topics.

Title: Law and Medicine

Number of hours: 25

Institution(s): Università Campus Bio-Medico di Roma and Gnosis Research Institute

Location(s): Online

Type: Ph.D. course

Attendance Mode: Mainly online

Final Exam: Yes, a personal PowerPoint presentation of 15-20 slides related to topics covered in the course.

Lecturer(s): Dr. Stefano Regondi, email: stefano.regondi@figliesancamillo.it; s.regondi@gnosistech.ai.

Responsible Expert(s)\email: Dr. Stefano Regondi, email: stefano.regondi@figliesancamillo.it, Generale Director Istituti Ospedalieri Figlie San Camillo (RM,CR,BS,TR,TN,CH,CA), Scientific Director GNOSIS RESARCH INSTITUTE

Academic Year: 2025-2026

Semester: 2

Timetable:

The course will be held in 3 months considering approximately 10 h a month for lectures. The proposed dates are:

Thursday 05/03/2026 h 11.00-13.00 Online

Thursday 12/03/2026 h 11.00-13.00 Online

Thursday 19/03/2026 h 11.00-13.00 Online

Thursday 26/03/2026 h 11.00-13.00 Online

Thursday 02/04/2026 h 11.00-13.00 Online

Thursday 09/04/2026 h 11.00-13.00 Online

Thursday 16/04/2026 h 11.00-13.00 Online

Thursday 23/04/2026 h 11.00-13.00 Online

Thursday 30/04/2026 h 11.00-13.00 Online

Wednesday 07/05/2026 h 11.00-13.00 Online

Wednesday 14/05/2026 h 11.00-13.00 Online

Wednesday 21/05/2026 h 10.00-13.00 Final exam (online or Dr. Regondi is available at IFSC Rome)
Students who wish to attend the course are invited to contact the lecturer to enroll in the course.

Abstract:
In an era where science and technology rapidly evolve, the interplay between law and these domains becomes increasingly significant. This course offers a comprehensive exploration of the legal, ethical, and policy issues at the intersection of law, medicine, and technology. The curriculum focuses on how legal frameworks adapt to and shape advancements in several scientific fields, particularly genetics, biotechnology, artificial intelligence (AI), and robotics.
This course aims to equip students with a profound understanding of the legal challenges posed by scientific and technological advancements. Through a blend of theoretical and case-based learning, students will gain insights into the dynamic legal landscape surrounding cutting-edge technologies, preparing them to navigate and shape the future of law in the age of technology.

Learning Outcomes:

1. Understanding AI and Legal Frameworks: Students will gain a comprehensive understanding of the legal frameworks governing AI research, including international and national regulations, data protection laws, and intellectual property rights.
2. Ethical Principles in AI Research: Students will learn the fundamental ethical principles guiding AI research, including respect for autonomy, beneficence, non-maleficence, and justice. They will be able to identify ethical challenges specific to AI, such as bias, transparency, and accountability.
3. Protocol Development for Ethical Committees: The course will equip students with the skills to develop and submit scientifically rigorous and ethically sound research protocols to Ethical Committees. This includes the ability to articulate the research's purpose, methodology, potential impacts, and ethical considerations.
4. Critical Analysis of AI in Healthcare: Students will critically analyze the use of AI in healthcare, evaluating the ethical implications of AI-driven diagnostics, treatment planning, and patient data management.
5. Case Study Analysis: Through the examination of real-world case studies, students will learn to apply legal and ethical frameworks to practical scenarios, enhancing their problem-solving and decision-making skills.

Detailed lecture contents:
The study of how law interacts with medicine and technology is more critical and relevant now than before. In the course we will examine these following topics:

I. Medical Artificial Intelligence: Law & Policy

II. Legal Analytics and AI for Health Sources

III. Computational models of legal and ethical reasoning

IV. Regulation of Robotics, AI-based robotic surgery and Related Ethical Issues

V. Privacy and Security with New Technology Cybercrime and Computer Forensics / Computer forensics and security

VI. IPR and New Medical Technology

VII. Regulation (EU) 2016/679 of 27 April 2016 on the protection of natural persons regarding the processing of personal data and on the free movement of such data and repealing Directive 95/46/EC (General Data Protection Regulation) in research and clinical activities

VIII. Regulation (EU) 2017/745 of 5 April 2017 on the use of medical devices

IX. Regulation (EU) 2024/1689 on the use of AI (AI ACT)

X. Regulation (EU) 2024/1689 on the use of AI (AI ACT)

XI. Medical-Legal cases

Teaching method:
The course is structured with some theoretical lessons supported by slides provided by the lecturer and with some practical lessons regarding legal cases.

Final Exam:
The student will prepare slides solving or discussing a topic related during the course (min 15slides/max 20slides). The topic will be either proposed by the teacher or chosen by the student.

Prerequisites:
None

Key Bibliography:

- 1. *Artificial Intelligence Law*, Publisher: Intersentia, Publication Year: 2023, Link to the book
- 2. *Artificial Intelligence and Machine Learning in Health Care and Medical Sciences*, Springer, 2024, Link to the book

Title: Big Data in Healthcare

Number of hours: 25

Institution(s):University of Messina

Location(s): Online

Type: Ph.D. course

Attendance Mode: Online

Final Exam: Yes

Lecturer(s): Prof. Antonio Celesti

Responsible Expert(s)\email: Prof. Antonio Celesti, University of Messina, email: acelesti@unime.it

Academic Year: 2025/2026

Timetable:

2nd Semester academic year 2025-2026

Abstract: The use of Big Data in biomedical and health sciences has received a lot of attention in recent years. These pieces of data present a significant opportunity for the improvement of the diagnosis, treatment and prevention of various diseases, and to interventions to improve health outcomes. The objective of the course is to provide the basic knowledges to understand, design, develop Big Data Systems. Morevover, particular attention will be given to methodologies and software tool for Big Data Storage, Warehousing and advanced Machine Learning based Analytics. In the end, case studies on the adoption of Big Data in healthcare will be discussed.

Learning Outcomes:
-Understanding Big Data and how the way to manage information changes with respect to the past;
-Understanding NoSQL DBMS for Big Data;
-Acquire the skills to design and develop Big Data Warehouse systems;
-Acquire the skills to design and develop advanced Big Data Analytics systems based on Machine Learning;
-Understand how Big Data systems can be used to address healthcare problems.

Detailed lecture contents:

Introduction to Big Data. Understanding Big Data; Evolution of Big Data; Failure of Traditional Database in Handling Big Data; 3Vs of Big Data; Sources of Big Data; Different Types of Data; Big Data Infrastructure; Big Data Life Cycle; Big Data Technology; Big Data Storage; NoSQL DBMS; Driving Big Data with the Hadoop Technology; Big Data Applications; Big Data Use Cases.

Big Data Analytics. Terminology; Life Cycle; Analytics Techniques; Semantic Analysis; Visualanalysis; Business Intelligence; Real-Time Analytics Processing; Enterprise Data Warehouse; Machine Learning.

Improving Healthcare with Big Data. Big Data and Health; Big Data and Health in Low- and Middle-Income Countries; Analytical Challenges; Ethical Challenges;

Healthcare Data Analytics. Healthcare Data Sources and Basic Analytics (Electronic Health Records; Biomedical Image Analysis, Sensor Data Analysis, Biomedical Signal Analysis, Genomic Data Analysis, Clinical Text Mining, Mining Biomedical Literature, Social Media Analysis); Advanced Data Analytics for Healthcare (Clinical Prediction Models, Temporal Data Mining, Visual Analytics, Clinico–Genomic Data Integration, Information Retrieval, Privacy-Preserving Data Publishing); Applications and Practical Systems for Healthcare (Data Analytics for Pervasive Health, Healthcare Fraud Detection, Data Analytics for Pharmaceutical Discoveries, Clinical Decision Support Systems Computer-Aided Diagnosis, Mobile Imaging for Biomedical Applications); Extracting Disease Surveillance Information.

Teaching method:
The course is structured with four theorical lessons supported by slides provided by the lecturer and with one practical lesson focusing on the Apache Hadoop framework.

Final Exam: Knowledge gained during the course will be assessed with a pitch discussing a Big Data problem that can be addressed with a software tool of the Apache Hadoop framework chosen by the student. No additional time for the finalexam is needed, since it is already scheduled as part of the course.

Prerequisites: no prerequisite is required.

Key Bibliography:

1. Pouria Amirian, Trudie Lang, Francois van Loggerenberg. Big Data in Healthcare: Extracting Knowledge from Point-of-Care Machines. Springer Cham, eISBN: 978-3-319-62990-2.
2. Chandan K. Reddy, Charu C. Aggarwal. HealtHcare Data analytics. CRC Press, eISBN: 9780429183447
3. Sergio Consoli, Diego Reforgiato Recupero, Milan Petković. Data Science for Healthcare: Methodologies and Applications, Springer, eISBN 978-3-030-05249-2.
4. Rahul K., Banyal R.K., Arora N. A systematic review on big data applications and scope for industrial processing and healthcare sectors (2023) Journal of Big Data, 10 (1), art. no. 133

5. Venkatraman S., Parvin S., Mansoor W., Gawanmeh A. Big data analytics and internet of things for personalised healthcare: opportunities and challenges
6. (2023) International Journal of Electrical and Computer Engineering, 13 (4), pp. 4306 - 4316.
7. Arfaoui N. A new process for healthcare big data warehouse integration (2023) International Journal of Data Mining, Modelling and Management, 15 (3), pp. 240 - 254
8. Chao K., Sarker M.N.I., Ali I., Firdaus R.B.R., Azman A., Shaed M.M. Big data-driven public health policy making: Potential for the healthcare industry
9. (2023) Heliyon, 9 (9).
10. Alzaabi H.M., Alawadhi M.A., Ahmad S.Z. Examining the impact of cultural values on the adoption of big data analytics in healthcare organizations (2023) Digital Policy, Regulation and Governance , 25 (5), pp. 460 - 479
11. Sangaiah A.K., Rezaei S., Javadpour A., Zhang W. Explainable AI in big data intelligence of community detection for digitalization e-healthcare services
12. (2023) Applied Soft Computing, 136.

Title: Knowledge Engineering

Number of hours: 25

Institution(s): University of Campania "Luigi Vanvitelli"

Location(s): Department of Engineering – via Roma n. 29 – Aversa (CE) / Online

Type: PhD Course

Attendance Mode: Online/Phygital

Final Exam: Yes

Lecturer(s): Beniamino Di Martino, Luigi Colucci Cante, Mariangela Graziano

Responsible Expert(s)\email: Beniamino Di Martino - Università della Campania "Luigi Vanvitelli" – beniamino.dimartino@unicampania.it – luigi.coluccicante@unicampania.it – mariangela.graziano@unicampania.it

Academic Year: 2024/2025, 2025/2026

Semester: 2

Timetable: from September to December 2026. Students who wish to attend the course are invited to contact the lecturer by mid-February. Specific dates will be communicated to interested students.

Abstract:
The course introduces the topics and concepts of the field of Artificial Intelligence that deals with the Representation and Management of Knowledge, through methods and techniques based mainly on Logic and the production of rules. After an introduction, focused on the presentation of concrete examples of Intelligent Systems based on Rule-based techniques, we start with an overview of Problem-Solving techniques based on Research in State Spaces. The main models for the Representation of Knowledge are then introduced, with an in-depth study dedicated to the architecture and languages of the Semantic Web. We then move on to models and techniques of automated reasoning based on deduction and inference, in particular models based on Logic, with particular attention to the language of inference for the Semantic Web – SWRL. Finally, important fields of application of the methods illustrated are presented: Natural Language Processing, Process Mining and Semantic Web Services.

Learning outcomes:

Detailed lecture contents:

Introduction to AI

Genesis and Challenges of Artificial Intelligence

Intelligent Systems: Examples from the Past and Present

Models and Techniques for Knowledge's Representation

Introduction to Knowledge Based Systems

Classical Models of Knowledge Representation: Semantic Networks, Conceptual Graphs, Frames, Scripts, Triple OAV

Wordnet, an example of a Semantic Network

Semantic Web

Introduction to Semantic Web and its Stack

RDF and RDFS Metadata Description Languages

Open Data and Linked Open Data

OWL: a Semantic Web Language for managing ontologies

Creation of OWL ontologies with Protege Tool

Semantic Web Services with OWLS

Reasoning and related languages for the Semantic Web

Logic-based reasoning models

An RDF/OWL Query Language: SPARQL

An Inference Language for the Semantic Web: SWRL

Process Mining and Multi-agent Systems

Introduction to Process Mining as a Link between Data Science and Process Science

Process Mining Techniques

Overview of main Process Models

Algorithms for Process Mining Discovery

Representational Bias, Noise, Incompleteness and Quality Assessment of Discovered Process Models

Algorithms for Process Mining Conformance Checking

Additional Perspectives of Process Mining: Organizational Mining (Social Network Analysis and Role Discovery), Case Perspective (Decision Mining), Time Perspective

Introduction to Process Mining Operation Support

Process Mining Tool: Introduction to ProM

Introduction to agents

Multi-agent systems

Semantic Agents

Natural Language Processing

Introduction to Text Mining, Natural Language Processing Levels and NLP Pipeline

Text Pre-Processing Techniques: stopwords removal, lemmatization, stemming, regex

Text Analysis Techniques: Named Entity Recognition and POS-Tagging

Natural Language Processing Libraries: NLTK and SPACY illustration

Text Vectorization Techniques: Bag of Word, TF-IDF

Word Embedding algorithms: Word2Vec (Skip-Gram and CBOW architectures) and GloVe

Semantic Annotation of Text, with illustration by Open Source and Free Annotators

Application of Deep Learning to NLP

A Text Generation overview: Recurrent Neural Network (RNN), Transformers, Generative Adversarial Networks (GAN)

Teaching method: lectures and lab. Most of the lectures will be given in Italian Language, and part of them will be teached asynchronously, through a MOOC platform.

Final exam: Home assignment and oral discussion of it

Prerequisites: Procedural Programming skills, notions of Boole Algebra, Graphs and databases

Key bibliography:

George F. Luger – Artificial Intelligence: Structures and Strategies for Complex Problem Solving – Addison Wesley
Grigoris Antoniou et al. – A Semantic Web Primer – MIT Press
Leon Sterling, Ehud Shapiro – The Art of Prolog – MIT press
Wil M. P. van der Aalst - Process Mining - Discovery, Conformance and Enhancement of Business Processes
Steven Bird, Ewan Klein, and Edward Loper - Natural Language Processing with Python – Analyzing Text with the Natural Language Toolkit

UNIVERSITÀ CAMPUS BIO-MEDICO DI ROMA

Title: Hands-on Machine Learning & Deep Learning

Number of hours: 20

Institution(s): Università Campus Bio-Medico di Roma

Location(s): Università Campus Bio-Medico di Roma, Via Álvaro del Portillo, 21, 00128 Roma

Type: Ph.D. course

Attendance Mode: Phygital

Final Exam: Yes

Lecturer(s): Valerio Guarrasi

Responsible Expert(s)\email: Valerio Guarrasi, valerio.guarrasi@unicampus.it

Academic Year: 2023/2024, 2024/2025

Semester: 2 semester a.a. 2023/2024, 2024/2025

Timetable: The course will be held in 6 lectures during the second half of March. Students who wish to attend the course are invited to contact the lecturer by mid-February. Specific dates will be communicated to interested students.

Abstract:
In this course, students will gain an understanding of Machine Learning and Deep Learning concepts, algorithms, and applications. They will learn how to develop and implement various Machine Learning models using Python and acquire the skills to choose the appropriate models for different types of problems. Building intuition for these models and their practical uses is a key objective, along with mastering the skills for making accurate predictions and robust analyses.

Learning Outcomes:
Upon completion, students will have the practical knowledge to apply Machine Learning models to real-world problems, with a particular skill in selecting and applying the right model for each situation. They will be competent in handling and analyzing data, making predictions, and have proficiency in Deep Learning techniques for complex problem-solving. The course also aims to develop the capability to initiate, develop, test, and refine Machine Learning projects

Detailed lecture contents:
The Machine Learning Process (3h):

- Introduction to Machine Learning
- Data Preprocessing

Regression Models (4h):

- Simple Linear
- Multiple Linear
- Polynomial Regression
- Bias vs Variance, overfitting
- Support Vector Regression
- Decision Tree Regression
- Random Forest Regression
- Evaluating Regression Models

Classification Models (3h):

- Logistic Regression
- k-NN
- SVM
- Kernel SVM
- Naive Bayes
- Decision Tree Classification
- Random Forest Classification
- Evaluating Classification Models

Clustering Techniques (4h):

- K-Means
- Hierarchical Clustering
- DB-Scan
- Expectation-Maximization
- Evaluating Clustering Models

Deep Learning (6h):

- Artificial Neural Networks
- Convolutional Neural Networks
- Autoencoders

Teaching method:
Interactive Lectures: To introduce and explain key concepts.
Hands-on Tutorials: Python-based exercises for practical experience.
Case Studies: Real-life examples to illustrate the application of theories.

Final Exam:
Knowledge gained during the course will be assessed with a project work based on the development and performance of models in a practical project.

Prerequisites:
Basics of programming

Key Bibliography:
Bishop, Christopher M., and Nasser M. Nasrabadi. Pattern recognition and machine learning. Vol. 4. No. 4. New York: springer, 2006.

Etica Personalista Applicata all'Intelligenza Artificiale

Vittoradolfo Tambone, Giampaolo Ghilardi, Nicola Di Stefano, Francesco De Micco

7h - A/A 2025-2026

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1. Introduzione all'Etica Personalista

- **1.1 Fondamenti del Personalismo**
  - La persona umana.
  - Relazione persona-persona; persona-natura; persona-tecnologia.
  - Trascendenza.
- **1.2 Il Personalismo e l'Etica**
  - Persona umana e felicità.
  - Virtù relazionali.

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2. L'AI alla Luce del Personalismo

- **2.1 Rilettura Personalista della Tecnologia**
  - La tecnologia come alterazione rafforzativa della persona.
  - Tecnologia come Atto Umano.
- **2.2 AI e Antropologia Personalista**
  - Differenza qualitativa tra persona e macchina.
  - Libertà della persona e gradi di libertà della macchina.
  - Correlazione e Interpretazione.

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3. Principi Etici Personalisti Applicati all'uso della AI

  - Non esiste un'Etica della AI.
  - Oltre l'implicito economico e politico della progettazione di Algoritmi.
  - Distinguere il discorso analogico da quello identitario nella dinamica AI/HI.

4. Casi Studio Personalisti sull'AI in Life Science

  - Diagnosi assistite da AI: il falso confronto fra decisioni umane e algoritmiche.
  - Rinuncia all'uso della AI come Malpractice.
  - GAN Ibridi e Nuova Metodologia Clinica Ibrida.
  - Temperatura degli Algoritmi ed Evidence Based Medicine.

Metodologia Didattica

- **Lezioni frontali e dialogiche**: esplorazione dei fondamenti del personalismo e delle sue applicazioni (3h)
- **Analisi di casi studio**: rilettura di esempi reali attraverso la lente del personalismo (4h)

Valutazione

- Partecipazione attiva.
- Elaborati su casi di studio applicati ai principi personalisti.
- Progetto finale: proposta di un sistema di AI che rispetti i criteri etici personalisti.

UNIVERSITÀ CAMPUS BIO-MEDICO DI ROMA

Title: Introduction to Multi-Omics Sciences with Bioinformatics and Artificial Intelligence

Number of hours: 18

Institution(s): University of Siena

Location(s): Online

Type: Ph.D. course

Attendance Mode: Online

Final Exam: Yes

Lecturer(s): Prof. Fabrizio Celesti

Responsible Expert(s)\Email: Prof. Fabrizio Celesti, Department of Medicine, Surgery and Neuroscience, University of Siena, email: fabrizio.celesti@unisi.it.

Academic Year: 2025/2026

Timetable:

2nd Semester Academic Year 2025-2026.
Every Tuesday h. 08:30 - 10:30 and Thursday h. 08:30 - 11:30 from May 5th, 2026, to June 4th, 2026.

Abstract:
The course introduces the connection between bioinformatics and artificial intelligence (AI) within Multi-Omics Sciences, including genomics, transcriptomics, proteomics, and epigenomics. Its goal is to give students basic knowledge and practical skills to analyse large biological datasets using modern computational tools and basic AI-based methods.
Main topics include an overview of essential biology concepts, different types of omics data and the technologies used to produce them. The course also covers basic statistical and computational methods for processing and combining these data. Central focus is given to biomarker discovery, precision medicine, and network-based Multi-Omics analysis. Students will also have basic experience with software tools and programming languages (e.g., R).
By the end of the course, students will be able to design and run simple analysis workflows for Multi-Omics data, critically assess basic AI models used in biological research, and contribute to new applications in systems biology and personalised medicine. The course is suitable for students in biology, biotechnology, bioinformatics, computer science, or related fields who want to strengthen their skills in the growing area of bioinformatics and AI applied to Multi-Omics Sciences.

Learning Outcomes:

- **Comprehensive understanding of basic biology**. Acquire basic knowledge of biological concepts and understanding of biological data sources.
- **Comprehensive understanding of Multi-Omics data**. Gain a deep understanding of the principles, methodologies, and challenges related to Multi-Omics data.
- **Understanding of how to develop Multi-Omics workflows.** Acquire how to build and implement workflows for data preprocessing, normalization, integration, and interpretation, enabling robust and reproducible Multi-Omics research.
- **Learn basic bioinformatics skills.** Develop expertise to analyse Multi-Omics data by using basic computational tools.
- **Learn basic use of AI in Multi-Omics research**. Learn how to design, apply, and evaluate basic AI-based approaches for extracting meaningful insights from Multi-Omics data.
- **Apply these skills to real biological questions.** Gain awareness of how to use Multi-Omics workflows to solve problems regarding biomarkers discovery, precision medicine, and systems biology.

Detailed Lecture Contents:

- **Introduction to Biological Data.** Definition and Sources of Biological Data; Characteristics of Biological Data; Applications of Biological Data; Challenges in Handling Biological Data.
- **Foundations of the Multi-Omics Science**. Introduction to Multi-Omics Data; Overview of Omics Layers (Genomics, Transcriptomics, Proteomics, Epigenomics); Technologies and Platforms Enabling Multi-Omics; Multi-Omics Workflow; Data Integration, Analysis and Interpretation.
- **Bioinformatics and AI applied to Multi-Omics.** Challenges in Multi-Omics Data Interpretation; Functional Annotation and Pathway Analysis; Basic Application of Bioinformatics and AI Tools; Methodological Limitations.
- **Healthcare Application in Multi-Omics.** Understanding Biological Systems; Biomarkers Discovery; Early Disease Diagnosis; Precision Medicine and Personalized Healthcare; Challenges in Multi-Omics Research; Future Perspectives.

Teaching Method: The course is structured with theoretical and practical lessons supported by slides.

Final Exam: Knowledge gained during the course will be assessed with a written exam. No additional time is needed since it is already scheduled as part of the course.

Prerequisites: No prerequisite is required.

Key Bibliography:

1. Manish Kumar Gupta, Pramod Katara, Sukanta Mondal, Ram Lakhan Singh. Integrative Omics: Concept, Methodology, and Application. Academic Press, eBook ISBN: 9780443160936.

2. Kang Ning. Methodologies of Multi-Omics Data Integration and Data Mining. Springer, eBook ISBN: 978-981-19-8210-1.
3. Mario Cannataro, Pietro Hiram Guzzi, Giuseppe Agapito. Artificial Intelligence in Bioinformatics: From Omics Analysis to Deep Learning and Network Mining. Elsevier, eBook ISBN: 9780128229293.
4. Adam Bohr, Kaveh Memarzadeh. Artificial Intelligence in Healthcare. Academic Press, eBook ISBN: 9780128184394.
5. Shailza Singh. Machine Learning and Systems Biology in Genomics and Health. Springer, eBook ISBN: 978-981-16-5993-5.
6. Abedalrhman Alkhateeb, Luis Rueda. Machine Learning Methods for Multi-Omics Data Integration. Springer, eBook ISBN: 978-3-031-36502-7.
7. Momiao Xiong. Big Data in Omics and Imaging: Association Analysis. Chapman and Hall/CRC, eBook ISBN 9781315370507.
8. Debmalya Barh, Vasco Ariston De Car Azevedo. Omics Technologies and Bio-engineering. Academic Press, eBook ISBN: 9780128047491.
9. Loo Keat Wei. Computational Epigenetics and Diseases. Academic Press, eBook ISBN: 9780128145142.

Title: Network Science and Applications in Biology, Health Sciences, and Neuroscience

Number of hours: 12

Institution(s): Università di Bari

Location(s): Online

Type: Ph.D. course

Attendance Mode: Online

Final Exam: Yes

Lecturer(s): Nicola Pedreschi, Giulio Pergola

Responsible Expert(s)\email: Nicola Pedreschi, Università di Bari, nicola.pedreschi@uniba.it

Academic Year: 2024/2025

Semester: 2, April/May 2026

Abstract:
This course integrates Network Science with a focus on its applications in biology, health sciences, and neuroscience. Participants will explore how complex biological systems, such as (among others) gene co-expression networks and neural networks, can be modeled through network theory. The course aims to equip students with the tools to analyze biological networks and apply network-based approaches to address multifaceted research challenges.

Learning Outcomes:
By the end of the course, students will be able to:

- Understand the foundational principles of Network Science
- Analyze biological phenomena using network models.
- Apply network analysis techniques to study neural connectivity and brain function.
- Interpret complex datasets through network analysis within biological and health contexts.
- Critically evaluate the implications of network-based approaches in both biological research and neuroscience.

Detailed lecture contents:

1. Introduction to Network Science (2h)
    - Overview of network theory and concepts
    - Importance of networks in biological contexts
2. Network Analysis Techniques (2h)
    - Statistical methods for network analysis

    - Tools and software for analyzing networks (NetworkX, graph-tool, Gephi, XGI)
3. Biological Networks (2h)
    - Types of biological networks (e.g., gene regulatory, protein-protein interaction networks, Structural and Functional Brain networks)
    - Case studies illustrating the application of networks in biology
    - Tutorial
4. Applications in Health Sciences (2h)
    - Use of networks in disease modeling and epidemiology
    - Network-medicine
    - Tutorial
5. Practical Sessions: Case Studies and Applications (4h)
    - Hands-on analysis of biological networks using real datasets

Teaching method:
The course is structured with theoretical lessons supported by slides provided by the lecturer and practical examples/tutorials at the computer using Python language on free online environments.

Final Exam:
Assessment will be based on a presentation discussing a research paper or project related to network science and its applications in biology and health sciences.

Prerequisites:
Basic understanding of data analysis techniques and of the programing language Python are recommended. Familiarity with network theory is advantageous but not mandatory.

Key Bibliography:

- Newman, M. E. J. (2010). Networks: An Introduction. *Oxford University Press*.
- Sporns, O. (2011). Networks of the Brain. *MIT Press*.
- Barabási, A.-L., & Oltvai, Z. N. (2004). Network Biology: Understanding the Cell's Functional Organization. *Nature Reviews Genetics*
- Barabàsi, A.-L., Gulbahce N., Loscalzo J. (2010). Network Medicine: a network-based approach to huma disease. *Nature Reviews Genetics*

UNIVERSITÀ CAMPUS BIO-MEDICO DI ROMA

National PhD in Artificial Intelligence
Area of specialization: Health and Life Sciences

Title: The AI Act and its operational interaction with the GDPR

Number of hours: 10

Institution(s): Università Campus Bio-Medico di Roma/GP4AI/Università di Bari

Location(s): On line

Type: Ph.D. course

Attendance Mode: On Line

Final Exam: Yes

Lecturer(s): Claudio Caldarola, with lectio magistralis presented by prof. Antonio Felice Uricchio, President of the Italian National Agency for the Evaluation of Universities and Research (ANVUR).

Responsible Expert(s)\email: Avv. Claudio Caldarola, Presidente GP4AI - Global Professionals for Artificial Intelligence / studioavvocatoclaudiocaldarola@gmail.com

Academic Year: 2025/2026

Semester: 2.

Timetable:
- 19 ottobre 2026, ore 11:00–13:00
- 21 ottobre 2026, ore 11:00–13:00
- 26 ottobre 2026, ore 11:00–13:00
- 28 ottobre 2026, ore 11:00–13:00
- 3 novembre 2026, ore 11:00–13:00

Abstract: The course provides a comprehensive introduction to the AI Act (EU Regulation 2024/1689), its classification of artificial intelligence systems based on risk levels, and the corresponding obligations for providers, developers, and users. Particular attention is dedicated to the interactions between the AI Act, the GDPR, and Italian legislation (Law 132/2025), with in-depth coverage of systemic risks, responsibilities, governance, data quality, Fundamental Rights Impact Assessments (FRIA), and Data Protection Impact Assessments (DPIA). The course also offers an overview of the first national regulations on AI in the healthcare sector, analyzing opportunities, constraints, and legal and ethical challenges. Through case studies and applied examples, students will acquire the skills needed to interpret, assess, and implement artificial intelligence solutions that comply with both the European and Italian regulatory frameworks.

Learning Outcomes: (1) Explain the structure, objectives, and regulatory scope of the AI Act; (2) Critically analyze the operational interplay between the AI Act, the GDPR, and Italian legislation (Law 132/2025); (3) Evaluate the legal, technical, and ethical implications of systemic-risk AI models; (4)

Assess the appropriateness of Fundamental Rights Impact Assessments (FRIA) and Data Protection Impact Assessments (DPIA); (5) Identify and interpret the regulatory constraints applicable to AI solutions in the healthcare sector; (7) Develop informed and legally sound approaches to AI governance and compliance; (8) Critically reflect on ethical challenges associated with AI deployment.

Detailed lecture contents: The course offers an overview of the AI Act, its objectives, scope, and foundational concepts, including the definition of AI systems and the classification framework based on risk levels. It examines the regulatory obligations for providers and deployers, with emphasis on risk management, data governance, transparency, human oversight, and conformity assessment. The treatment of General-Purpose AI models is introduced, together with the additional requirements for systemic-risk models. The course then addresses impact-assessment tools under the AI Act, focusing on the Fundamental Rights Impact Assessment and its relationship with the GDPR's Data Protection Impact Assessment. The interaction between the AI Act and the GDPR is explored through issues of data quality, accountability, and bias mitigation. A final component analyses the Italian Law 132/2025, with particular reference to AI applications in the healthcare sector, research activities, and data-processing operations. Applied examples and case studies illustrate practical compliance considerations.

Teaching method: lectures, hands-on sessions

Final Exam: project presentation

Prerequisites:No

Key Bibliography:

1. Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation). https://eur-lex.europa.eu/eli/reg/2016/679/oj?eliuri=eli%3Areg%3A2016%3A679% 3Aoj&locale =en
2. Regulation (EU) 2024/1689 of the European Parliament and of the Council of 13 June 2024 laying down harmonised rules on artificial intelligence and amending Regulations (EC) No 300/2008, (EU) No 167/2013, (EU) No 168/2013, (EU) 2018/858, (EU) 2018/1139 and (EU) 2019/2144 and Directives 2014/90/EU, (EU) 2016/797 and (EU) 2020/1828 (Artificial Intelligence Act). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32024R1689

UNIVERSITÀ CAMPUS BIO-MEDICO DI ROMA

National PhD in Artificial Intelligence
Area of specialization: Health and Life Sciences

Title: Artificial Intelligence for Mental Health and Well-being: Ethical Design, Applications and Evaluation

Number of hours: please insert any multiple of 5 from 10: 15

Institution(s): CNR – Istituto per la Ricerca e l'Innovazione Biomedica (IRIB), Messina

Location(s): please select among Physical address/Online: **Online**

Type: Ph.D. course

Attendance Mode: please select among In presence/Online/Phygital: **Online**

Final Exam: Yes

Lecturer(s): Flavia Marino

Responsible Expert(s)\email: name, affiliation and email(s): Flavia Marino, CNR-IRIB, flavia.marino@irib.cnr.it

Academic Year: 2025/2026

Semester: 1/2 (please consider that the course can be selected by the student in the first, second ot third year of the PhD.

Timetable:
Thursday, May 7, 2026 h.9:00-12:00
Tuesday, May 12, 2026 h.9:00-12:00
Thursday, May 14, 2026-h. 9:00-12:00
Tuesday, May 19, 2026 - h. 9:00-12:00
Thursday, May 21, 2026- h. 9:00-12:00.
Thursday, May 28, 2026 – 9:00 AM – 12:00 (final exam)

Abstract:
This course explores the use of Artificial Intelligence in the promotion of mental health and psychological well-being, analyzing digital tools and systems applied to assessment, prevention, and intervention in clinical, educational, and workplace settings. Topics include usability, acceptability, and ethical impact of AI-based technologies, with a focus on person-centered design and inclusion. Predictive models for early detection of psychological distress and use cases integrating AI, robotics, virtual reality, and telehealth will be discussed.

Learning Outcomes:
- Understand key AI applications in mental health and well-being promotion
- Analyze user-centered design models for AI-based digital tools
- Evaluate usability, acceptability, and ethical/social implications of AI solutions
- Recognize predictive approaches for early detection of psycho-emotional issues

- Apply multidisciplinary principles to integrate AI into healthcare and psychosocial contexts

Detailed lecture contents:
1. Introduction to digital mental health and well-being
2. AI, data science, and digital tools for mental health
3. Predictive systems and personalized intervention models
4. Ethical and inclusive interfaces: robotics, VR, and smart environments
5. Acceptability by users and professionals: theoretical models and evidence
6. Use cases: from clinical settings to workplace applications
7. Guidelines and regulatory frameworks (WHO, EU, APA, GDPR)
8. Evaluation of tools: usability, effectiveness, sustainability

Teaching method:
Lectures with interactive discussion, case study analysis, critical reading of scientific papers, practical exercises on applied scenarios and evaluation tools.

Final Exam:
Written paper with a critical reflection on an AI application in mental health or a project proposal based on a real-life scenario.

Prerequisites:
Basic knowledge in psychology, cognitive science, health sciences, or biomedical engineering. Interest in interdisciplinary applications of AI.

Key Bibliography:
- Topol, E. (2019). Deep Medicine: How Artificial Intelligence Can Make Healthcare Human Again. Basic Books.
- Mittelstadt, B., & Floridi, L. (2016). The ethics of big data: current and foreseeable issues in biomedical contexts. Science and Engineering Ethics.
- WHO (2021). Guidance on Ethics & Governance of Artificial Intelligence for Health

Title: Docker is All You Need: Hands-On Containerization for Reproducible Research

Number of hours: 10 ore

Institution(s): University Campus Bio-Medico di Roma

Location(s): Via Álvaro del Portillo, 21, Roma / (Microsoft Teams link)

Type: Ph.D. course

Attendance Mode: The attendance mode will be Phygital.

Final Exam: Yes

Lecturer(s): Ermanno Cordelli

Responsible Expert(s)\email: Ermanno Cordelli (e.cordelli@unicampus.it), University of Salento, University Campus Bio-Medico di Roma

Academic Year: The academic years will be 2025/2026.

Semester: Semester 1

Timetable: Classes will be held in February 2026 on the following dates:
Tuesday 10 - 15:00 to 17:00
Friday 13 - 15:00 to 17:00
Tuesday 17 - 15:00 to 17:00
Friday 20 - 15:00 to 17:00
Tuesday 24 - 15:00 to 17:00

Abstract: Research reproducibility remains a critical challenge in academia and enterprising application. Machine learning models that function on one system often fail on another due to dependency conflicts. Data pipelines break across operating systems because of path inconsistencies. Collaborators face prolonged setup times with environment-specific installations, while "it works on my machine" issues undermine collaboration and delay progress. Whether deploying AI frameworks like PyTorch, robotics frameworks such as ROS, or any computational workflow, these problems hinder scientific advancement across disciplines.

Docker addresses these issues effectively. It packages Python applications, data processing scripts, robotics frameworks, and environments into portable containers that execute consistently across Windows, macOS, Linux, and external drives. Researchers can share immutable images through registries like Docker Hub and manage multi-service applications using Docker Compose for APIs, queues, databases, and sensor simulations.

This approach enables reliable builds, streamlined workflows compatible with version control systems, and platform-independent deployment, converting fragile experiments into dependable, shareable research outputs.

Learning Outcomes: Portable Docker setup across OSes, Core container management, Python Dockerfile creation, Volumes and networking, Docker Compose orchestration

Detailed lecture contents:
Lesson 1: Portable Setup and Container Fundamentals
Explore Docker installation on external drives across OSes. Introduce basic container lifecycle and simple Python examples.

Lesson 2: Essential Docker Operations
Cover core CLI commands for managing Python containers and data persistence. Hands-on troubleshooting with bind mounts.

Lesson 3: Building Custom Images
Develop Python-focused Dockerfiles with optimization techniques. Experiment with builds from portable storage.

Lesson 4: Storage, Networking, and Connectivity
Investigate volumes, networks, and service communication. Test multi-container interactions.

Lesson 5: Multi-Service Orchestration with Compose
Introduce Docker Compose for application stacks. Build and scale Python-based services.

Teaching method: Classroom lessons (with slides support) and practical lessons (using own computer).

Final Exam: Students develop and submit a Docker image containing their original Python software (e.g., data pipeline, Flask API, ML script, ROS node simulation), plus a README guide for installation/running.

Prerequisites: Python scripting (basics) and terminal/CLI on your OS (basics).

Bibliography:

Key Free Books**:**
[1] *Practical Docker with Python* (S. Bhat, 2018)
[2] *Docker Cookbook* (S. Goasguen)

Key Free Text References:
[1] *Official Docker Python Guide*
[2] *Docker Curriculum*
[3] *Real Python Docker Tutorials*
[4] *Python Engineer Docker Intro*
[5] *Manchester Uni Docker Hello World*