COURSE OF STUDY *Physics (LM-17)*

ACADEMIC YEAR *2023-2024*

ACADEMIC SUBJECT *Deep Learning and Generative Models*

General information	
Year of the course	2nd
Academic calendar (starting and ending date)	1st semester: September - December 2023
Credits (CFU/ECTS):	3
SSD	FIS/01
Language	English
Mode of attendance	Compulsory

Professor/ Lecturer	
Name and Surname	Angelo Mariano
E-mail	angelo.mariano@enea.it
Telephone	0831201564
Department and address	Physics Department, room 144 A
Virtual room	
Office Hours (and modalities: e.g., by appointment, on line, etc.)	Monday (on request)

Work schedule			
Hours			
Total	Lectures	Hands-on (laboratory, workshops, working groups, seminars, field trips)	Out-of-class study hours/ Self-study hours
75	16	15	44
CFU/ECTS			
3	2	1	

Learning Objectives	Knowledge and understanding of deep learning algorithms both in supervised, unsupervised and reinforcement learning settings
Course prerequisites	Basic knowledge of at least one programming language and of linear algebra concepts

Teaching strategie	Slides presented by the teacher during lectures and interactive sessions on notebooks containing code describing different algorithms
Expected learning outcomes in terms of	
Knowledge and understanding on:	o Deep Learning foundations o Machine Learning and Artificial Intelligence problem setting and solving o Data-driven approach in Physics o Quantum computing use in Machine Learning
Applying knowledge and understanding on:	o Supervised learning problems o Unsupervised learning problems o Reinforcement Learning problems o Generative AI applications
Soft skills	• *Making informed judgments and choices* o Understand and develop a set of tools useful in Physics o Learn how to treat data to extract knowledge

	○ Understand how to design complex problems ● *Communicating knowledge and understanding* ○ Learn how to discuss a project and how to show it ○ Learn how to apply knowledge acquired to different contexts ● *Capacities to continue learning* ○ Acquire a reference framework to enter a data-driven approach
Syllabus	
Content knowledge	*Deep Learning in physics as a new paradigm in basic and applied research.* *Introduction to neural networks and python libraries (pandas, scikit-learn, matplotlib, scipy, tensorflow, pytorch).* *Deep learning systems: forward pass, loss functions, gradient, optimizers, backward pass, learning rate, regularization techniques.* *Deep supervised learning: convolutional networks, max and average pooling; recurrent neural networks, LSTM, GRU, convolutional LSTM and Transformers.* *Introduction to generative AI.* *Deep unsupervised learning: autoencoders, generative adversarial networks, adversarial training.* *Deep reinforcement learning: state, action, reward, Markov decision processes, Deep Q-learning, Bellman's equation.* *Introduction to quantum machine learning*
Texts and readings	*Slides provided by the teacher*
Notes, additional materials	
Repository	All the course content will be available on a shared repository

Assessment	
Assessment methods	Oral presentation (100%) starting from a research project assigned by the teacher
Assessment criteria	● *Knowledge and understanding* ○ Knowledge of principles of Deep Learning and of all the algorithms presented in the course ● *Applying knowledge and understanding* ○ Ability to apply knowledge acquired to different contexts ● *Autonomy of judgment* ○ Ability to understand which algorithm could be good for solving specific scientific problems ● *Communicating knowledge and understanding* ○ Clarity and precision of presentation ● *Communication skills* ○ Ability to present effectively the project and to explore different areas of deep learning and generative models ● *Capacities to continue learning* ○ Ability to identify needs and solutions that can be provided by the algorithm treated in the course
Final exam and grading criteria	Effectiveness, deep understanding of the subject, clarity of exposition.
Further information	
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