



UNIVERSITÀ
degli STUDI
di CATANIA

DIPARTIMENTO DI FISICA E ASTRONOMIA

“ETTORE MAJORANA”

DOTTORATO DI RICERCA IN FISICA

CICLO XL A.A. 2024/2025

A practical introduction to deep learning in physics

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Reception hours : Tuesday 11:00-13:00, Wednesday 15:00-17:00 and upon request.

Program of the course

The course offers an overview of modern machine learning techniques and provides ready-for-use tools for the analysis of complex and/or large datasets in basic and applied physics (and scientific in general) research.

More than half of the lectures are dedicated to hands-on sessions, to gain practical knowledge on common deep neural network applications and the skills necessary to autonomously develop and implement advanced models.

Syllabus

- 1) Introduction to machine learning
 - a) The artificial neuron model, the multilayer perceptron
 - b) The stochastic gradient descent and backpropagation algorithms
 - c) Deep Learning, bias-variance trade-off, double descend in deep neural networks
- 2) The programming framework
 - a) *Brushing up* the fundamental tools: Python, NumPy, SciPy, matplotlib, Jupyter notebooks, virtual environments
 - b) Tensorflow with Keras API
 - c) training and validation of a model with a simple architecture



- 3) Fundamental categories of machine learning algorithms
 - a) supervised vs unsupervised learning
 - b) regression, classification, clustering
 - c) generative learning
 - 4) Hands-on: convolutional deep neural networks for image classification
 - 5) Hands-on: autoencoders for anomalies detection and denoising
 - 6) Hands-on: tuning the model hyper-parameters using Scikit-Learn
 - 7) Hands-on: examples of generative neural networks
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Bibliography

- I. Goodfellow *et al.*, “*Deep Learning*”, MIT Press (2016)
<https://www.deeplearningbook.org/>
- J. VanderPlas, “*Python Data Science Handbook*”, O'Reilly Media, Inc. (2016)
<https://jakevdp.github.io/PythonDataScienceHandbook/>
- C. M. Bishop, H. Bishop, “*Deep Learning*”, Springer Cham (2023)
https://issuu.com/cmb321/docs/deep_learning_ebook
- Scientific papers and slides provided by the teacher