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: examples of generative neural networks

7) Hands-on: tuning the model hyper-parameters

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