



UNIVERSITÀ  
DEGLI STUDI DI MILANO-BICOCCA

## SYLLABUS DEL CORSO

### Ai Models for Physics

2223-1-F9102Q022

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#### Aims

The aim of this course consists of providing a set of general artificial intelligence methods to be applied to physical systems including quantum systems. The course prepares to conduct a professional approach to match most suitable machine learning tools to a physical problem. It enables to apply artificial intelligence in both scientific research and applied science environments, including reinforcement learning and quantum machine learning.

#### Contents

The course is divided in four main topics: application of deep supervised learning to hyper-resolution methods and symbolic models, application of deep reinforcement learning to control of quantum systems, deep unsupervised learning to physics with particular emphasis with the Ising model and the restricted Boltzmann machines, and quantum machine learning. Practical applications ranging from (and not limited to) econophysics to quantum technologies to medical physics are included.

#### Detailed program

Supervised learning - Convolutional networks for hyper-resolution of scientific images, the case of galaxy classification, graph neural networks, automated discovery of physical laws by symbolic models

Reinforcement learning - Reinforcement learning algorithms, density matrix formalism, master equation of quantum systems, Lindblad equation, coherent control of quantum states

Unsupervised learning – The Ising model, Markov chains, Metropolis algorithm, Gibbs sampling. Restricted Boltzmann machines for unsupervised learning. Autoencoders.

Quantum Machine Learning: quantum generative adversarial networks for generation of approximated distributions, training of variational quantum circuits for generation of entangled data

Epistemological aspects

## **Prerequisites**

Supervised learning methods, unsupervised learning methods, principles of quantum mechanics  
Last part on quantum machine learning takes advantage of the first part of the Quantum Simulation Course, held during the same semester.

## **Teaching form**

Lectures and laboratory programming activity. Both of them will be held in presence, unless further COVID-19 related restrictions are imposed. Attendance both to lectures and practical examples is warmly recommended. The programming activity refers to the program by computational lessons in which students can simulate the models. The computational part will take place in Python.

## **Textbook and teaching resource**

<https://www.deeplearningbook.org/> (free online)

Peter Wittek, Quantum Machine Learning: What Quantum Computing Means to Data Mining

Publisher: Academic Press ISBN: 9780128009536 (free PDF online)

## **Semester**

Second

## **Assessment method**

Students are required to prepare a written report on one of the laboratory activities, the exam will then consist in oral questions on the topics covered during lectures.

## **Office hours**

Wednesday 17:00-18:00

## **Sustainable Development Goals**

INDUSTRY, INNOVATION AND INFRASTRUCTURE

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