UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

SYLLABUS DEL CORSO

Calcolo non convenzionale e Quantistico

2223-2-F1801Q163

Aims

Understanding of the operating principles of some unconventional, bio-inspired and quantum computational models. Ability to understand how such systems work when solving computationally difficult problems. Ability to choose the most suitable computational model to solve an assigned problem.

Contents

Notions and concepts at the base of the Theory of Computation, and of the Theory of Computational Complexity, applied to unconventional and quantum computational models. The course also provides the conceptual and theoretical tools that allow to understand the mathematical bases on which the definition of the computational models examined is based.

Detailed program

For the Unconventional Computing part:
• Introduction: classical, sequential and parallel computing architectures
• Genetic algorithms and neural networks
• Neuroevolution
• DNA Computing: Adleman experiment, Lipton algorithm
• Membrane systems: standard model, membrane systems for computationally complex problems
• Spiking neural P systems

For the Quantum Computing part:
• Quantum physical phenomena, quantum parallelism, entanglement, measurements

• Mathematical notation: qubit, bra, ket, unit operators
• Quantum gates, their representation, and corresponding operators
• Quantum circuits
• Fundamental quantum algorithms: quantum Fourier transform, Shor's algorithms (factorization and discrete logarithms), Grover's algorithm
• Notes on other models: Quantum Turing machines, adiabatic Turing machines, ...
• Programming languages, libraries, simulators, platforms (in particular: QCEngine, Qiskit)
• Hybrid neural networks, and quantum machine learning

Prerequisites

Topics explained in mathematics courses held in the laurea degree in Informatics. It is useful - but not necessary - to have basic notions of theoretical computer science (in particular, Turing machines).

Teaching form

Lessons and exercises in the classroom.

The expected teaching language is English. However, lessons and exercises can be delivered in Italian if all students present in the classroom speak Italian, and no student requests to follow the lessons and exercises in English.

All lectures will be videorecorded, and videorecordings will be available on the course webpage.

Textbook and teaching resource

Textbooks:
• Andrew Adamatzky: Unconventional Computing - A Volume in the Encyclopedia of Complexity and Systems Science, Second Edition. Springer, 2018
• Wolfgang Polak, Eleanor Rieffel: Quantum Computing : A Gentle Introduction. MIT Press, 2011
• Eric R. Johnston, Nic Harrigan, Mercedes Gimeno-Segovia: Programming Quantum Computers: Essential Algorithms and Code Samples. O'Reilly Media, 2019

Lecture notes provided by the teachers.

Semester

Second semester, Academic Year 2022-2023

Assessment method

The learning assessment is based on an oral interview, on the subjects exposed in class during the course. During the interview, the student's ability to explain the topics of the course, and to make brief thoughts on them, will be assessed.

Office hours

On appointment

Sustainable Development Goals

QUALITY EDUCATION