UE Quantum Algorithm

Level
Baccalaureate +5

ECTS
3 credits

Component
UFR PhITEM (physique, ingénierie, terre, environnement, mécanique)

Semester
Automne

- **Teaching language(s):** English
- **Open to exchange students:** Yes
- **Code d'export Apogée:** PAX9QIAD

Presentation

Description

Teacher : Benoit Vermersch (UGA)

Objectives :

While the mathematical basis of quantum computing, the programming model, and most quantum algorithms have been published decades ago (starting in the 1990s), they have been of interest only to a small dedicated community. Time has come to make quantum algorithms and their implementations accessible to a broader audience aiming to explain the principles of quantum programming, which are quite different from those of classical programming. During these lessons and tutorials, you will learn Quantum Algorithms.

Program :

Lecture 1: *From classical computers to quantum computers*
- Classical computers in the circuit representation: Bits, gates, universality, computational complexity
- Motivations to build a quantum computer: Quantum parallelism and quantum speedup
- Introduction of quantum computing in the quantum circuit model
- Universal set of quantum gates – connection to entanglement
- The measurement

Lecture 2: *Quantum Algorithms*

- Warm-up: Deutsch's problem
- Data search: Grover’s algorithm
- Factorization: Shor’s algorithm

Lecture 3: *Quantum Error correction*
- The role of decoherence in a quantum circuit
- Introduction to repetition codes
- Stabilizer formalism.
- Quantum threshold theorem and fault-tolerant quantum computing. The example of surface codes

Lecture 4: *Quantum optimization I: Quantum annealing*
- Warm-up: Quantum adiabatic theorem
- Quantum annealing
- Fundamental limitations of quantum annealing

Lecture 5 : *Quantum optimization II: hybrid classical quantum Quantum annealing*
- Quantum approximation optimization algorithm (QAOA)
- Analog/Digital quantum Simulation.
- Solving quantum chemistry problems

– variational quantum eigensolver (VQE)

Lecture 6 : *Bonus lecture*
- Implementing a quantum oracle for Grover's algoritm
- Google's quantum supremacy and toric code experiments

Useful references: J. Preskill’s notes on quantum information: http://theory.caltech.edu/~preskill/ph229/ Quantum computation and quantum information, M. Nielsen, I. Chuang, Cambrige Press
Prerequisite: Quantum mechanics M1

Course parts

UE Quantum Algorithm - CMTD	Teaching Unit (UE)	24h

Period : Semester 9

Useful info

Campus

Grenoble - University campus