Quantum Machine Learning Engineering

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This course presents the main concepts and algorithms of quantum ML based on quantum circuits for digital architectures and introduces some methods of quantum ML algorithms on analog architectures.

Firstly, the course introduces embedding techniques in Hilbert space and some mechanisms for computing gradients or alternative solutions. Based on these mechanisms, the course presents various quantum algorithms for data clustering, neural networks and generative networks. Built around variational quantum algorithms and quantum circuits, they can run on digital current NISQ or future FTQC architectures to perform classifications or predictions.

Finally, the course introduces some quantum algorithms mainly designed for analog quantum architectures: QUBO optimization methods used to train some ML models and quantum reservoir algorithms.

Several tutorials and labs on digital or analog quantum development environments, with and without noise, and a few experiments on real QPUs, will fill the course.

Prerequisites:

Knowledge of quantum circuit programming is assumed, including Variational Quantum Algorithm. Knowledge of classical ML will be useful, but reminders will be given at the beginning of courses that require it.

Course outline:

Part I: Principles and basic mechanisms

1.	From ML to Quantum ML	Lesson: 1h30	
2.	Quantum embedding methods	Lesson: 1h30	Tutorial: 1h30
3.	Quantum gradient computing methods	Lesson: 1h30	

Part II: QML based on VQA and quantum circuits

4.	Quantum data clustering	Lesson: 1h30	Labs: 3h00
5.	Quantum Neural Networks	Lesson: 1h30	Tutorial : 1h30
6.	Quantum generator networks	Lesson: 1h30	Labs: 3h00
7.	Parallel circuits of neural networks	Lesson: 1h30	

Part III: QML on analog quantum architectures

8.	QUBO method for ML	Lesson: 1h30	
9.	Quantum reservoirs	Lesson: 1h30	Tutorial: 1h30

Some lessons include reminders of classic ML at the beginning