

Qiskit Optimization: Quantum algorithms for applications of optimization

Organisers

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Abstract

Optimization is one of the important application areas of near-term noisy quantum computers. Optimization plays an important role in decision making of various industries. Quantum-classical hybrid algorithms have been extensively studied in the last decade. The need of a versatile optimization framework for quantum computing arose in this context for research and education. Qiskit Optimization is an open-source framework that covers the whole range from high-level modelling of optimization problems, with automatic conversion of problems to different required representations, to a suite of easy-to-use quantum optimization algorithms that are ready to run on classical simulators, as well as on real quantum devices via Qiskit. This tutorial introduces the basics of the theory behind Qiskit Optimization and includes a hands-on session of how to define an optimization model and solve it with Qiskit Optimization.

Goals of the Workshop

We cover the basic concept of combinatorial optimization and review quantum algorithms to optimization problems in the first half. We explain the workflow to define optimization models and solve it with Qiskit Optimization using a simulator or a real device in the second half. The goal of this tutorial is that participants get used to define their practical optimization problems arising in the participants' research topic or industry and apply quantum algorithms to the problems to obtain good solutions.

Schedule of the Tutorial

10:30- 11:55 (85 min): Introduction of combinatorial optimization and quantum algorithms

- Overview of combinatorial optimization
- Classical-quantum hybrid scheme
- Noisy quantum computers
- How to convert optimization problems to Hamiltonians
- Quantum algorithms for optimization
 - Variational quantum algorithms (VQE)
 - Quantum approximate optimization algorithm (QAOA)
- Q&A

10 min break

12:05 – 13:30 (85 min): Hands-on: Qiskit Optimization workflow, how to define an optimization model and solve it

Workshop 1.3 at EQTC2021, Ireland

- Overview of Qiskit Optimization and Qiskit Terra
- Workflow to define and solve an optimization model
 - Basics of Docplex to define optimization models
 - Data flow of how a problem is converted into QUBO and executed on quantum computers
- Example: Maxcut
 - Define a Maxcut problem instance
 - Convert the instance to a Hamiltonian
 - Construct an ansatz
 - Solve the problem instance with VQE and QAOA
 - Solve the problem instance with noise model
- Exercise: TSP or other optimization problems
- Final remarks and Qiskit Optimization roadmap
- Q&A

Prerequisite from Participants

We expect participants to have an environment where "qiskit" and "qiskit-optimization" packages are installed (https://qiskit.org/documentation/getting_started.html). If they use IBM Quantum Lab (<https://quantum-computing.ibm.com/lab>), we expect them to verify their account beforehand. We also expect them to be familiar with Python, basic quantum computing / quantum information knowledge, and basic Qiskit. We recommend to check out Qiskit tutorials (<https://qiskit.org/documentation/tutorials.html>) and Qiskit textbook (<https://qiskit.org/textbook/preface.html>) to learn the basics of quantum computing and Qiskit.