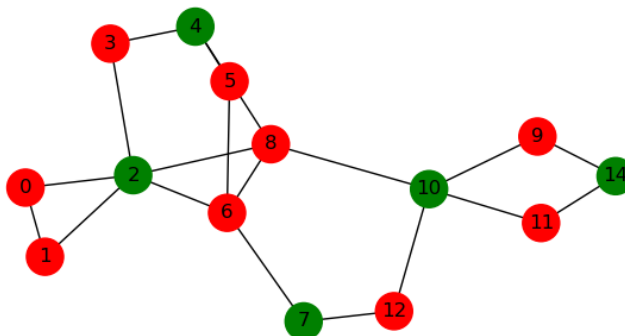


Topic 6: Solving MaxCut with simulated quantum annealing

What to expect

In this project, you will learn how to tackle a challenging optimization problem by transforming it into the search for the ground state of an Ising spin chain and leveraging Quantum Annealing to obtain the ground state. You will simulate this annealing dynamics using tensor network techniques. Proficiency in Python coding and a basic understanding of tensor network theory are useful.

Overview



QUBO problems pose a significant challenge in optimization, falling under the category of NP-hard problems with diverse applications spanning from finance to machine learning. These problems can be effectively translated into a ground state search for an Ising Hamiltonian and subsequently addressed through quantum annealing. We tackle a QUBO problem by simulating a suitable quantum annealing process using a TN ansatz.

Tasks

- Generate random instances of the MaxCut problem, with different connectivity and topology.
- Map a max-cut problem to a QUBO problem and solve it with a brute-force algorithm.
- Map a QUBO problem to ground state search and solve with quantum annealing (exact simulation).
- Map a larger QUBO problem to ground state search and solve by simulating quantum annealing with TN.
- Investigate how the capability of finding low energy states depends on the features of the MaxCut graph (e.g., average connectivity and topology). Which class of graphs is more suitable for the TN ansatz?
- Investigate how the capability of finding low energy states depends on the bond dimension, the annealing time, and the number of steps in the TDVP evolution.
- (Optional) Use OPES sampling⁸ for studying how the energy distribution evolves during the process.
- (Optional) Compare the performances of quantum annealing and variational GS search.

⁸M. Ballarin et al., arXiv pre-prints 2401.10330, 10.48550/arXiv.2401.10330 (2024).