Master-thesis: Extension of QAOA to constraint optimization problems

1 Background

Quantum computers can outperform classical computers on certain classes of problems and solve problems that are intractable even on any future (classical) supercomputer. The development of chips for quantum computers has been following Moore's law in the last years and the technology is edging ever closer to commercialization. Every new generation of quantum chips represents an improvement not only in the number of quantum bits, but also with respect to the error rates and the connectivity of the quantum bits. Most of these small scale quantum computers are accessible through cloud interfaces today. The first generation of practically-relevant quantum computers will be noisy intermediate-scale quantum (NISQ) computers. This means that calculations will have errors and the length of a computation will be relatively short. A family of methods that lend themselves well to NISQ devices are hybrid methods based on the variational principle. A general overview is provided in, e.g., [3].

2 Problems to be studied

For a range of real-world applications, constraints are of major importance, see e.g., [4]. However, it is not clear how to incorporate constraints in quadratic binary optimization problems suitable for quantum devices. Ideally, one can adapt both the initial state and the mixer such that the probability of going from a feasible state to an infeasible state (violating the constraints) is zero, see e.g., [2, 1].

3 Goals of the project

There are three primary goals of the project:

1. Developing a sound theoretical understanding of QAOA for various optimization problems, including basic principles and current state of the art.
2. Explore/design suitable strategies/mathematical framework to transform constraints for quadratic binary optimization problems.
3. Implementing and testing these on simulators and actual quantum computers. For execution on real devices, it is suggested to use e.g., IBM's gate based quantum computers available free online.

References

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