Quantum Circuit Optimization and Transpilation via Parameterized Circuit Instantiation

Ed Younis
Costin Iancu

Lawrence Berkeley National Laboratory, 1 Cyclotron Rd, Berkeley, CA 94720, United States

edyounis@lbl.gov

Parameterized circuit instantiation is a common technique encountered in the generation of circuits for a large class of hybrid quantum-classical algorithms [1, 2]. Despite being supported by popular quantum compilation infrastructures such as IBM Qiskit and Google Cirq, instantiation has not been extensively considered in the context of circuit compilation and optimization pipelines. In this work, we describe algorithms to apply instantiation during two common compilation steps: circuit optimization and gate-set transpilation. When placed in a compilation workflow, our circuit optimization algorithm produces circuits with an average of 13% fewer gates than other optimizing compilers. Our gate-set transpilation algorithm can target any gate-set, even sets with multiple two-qubit gates, and produces circuits with an average of 12% fewer two-qubit gates than other compilers. Overall, we show how instantiation can be incorporated into a compiler workflow to improve circuit quality and enhance portability, all while maintaining a reasonably low compile time overhead.

References

[1] Jarrod R McClean, Jonathan Romero, Ryan Babbush, and Al´an Aspuru-Guzik. The theory of variational hybrid quantum-classical algorithms. New Journal of Physics, 18(2):023023, 2016.

[2] Edward Farhi, Jeffrey Goldstone, and Sam Gutmann. A quantum approximate optimization algorithm. arXiv preprint arXiv:1411.4028, 2014.

[3] Seyon Sivarajah, Silas Dilkes, Alexander Cowtan, Will Simmons, Alec Edgington, and Ross Duncan. t— ket¿: a retargetable compiler for nisq devices. Quantum Science and Technology, 6(1):014003, 2020.

Figures

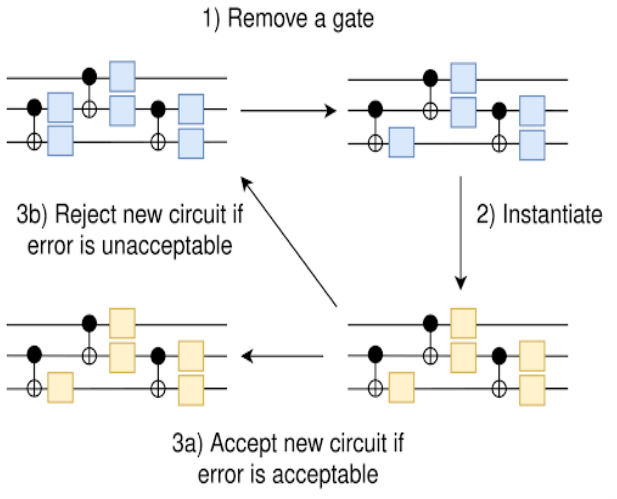

Figure 1: Gates can be removed from circuits through the use of instantiation. This can be done by first selecting and removing a gate, then instantiating the remaining gates' parameters to make up for the loss. This is not always successful. If the error on the new circuit is less than some threshold then the new circuit is accepted, otherwise the circuit is rejected.