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Randomized Benchmarking Beyond Groups, with Clifford XEB as an application

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Abstract

Randomized benchmarking (RB) is the gold standard for experimentally evaluating the quality of quantum operations. The current framework for RB is centered on groups and their representations but this can be problematic. In this work, we formulate the universal randomized benchmarking (URB) framework, which does away with the group structure. Not only does this framework cover most of the existing benchmarking schemes but it also gives the language for and helps inspire the formulation of new schemes. We specifically consider a class of URB schemes called twirling schemes and prove that under some condition, the probability of measurement as a function of gate length is a single exponential decay up to small error terms. As an application, we investigate the theoretical foundation of the linear XEB, and propose a variant using Clifford circuits, which allows efficient classical post-processing and supports holistic benchmarking of over 1,000 qubits. In addition, we run numerical simulations for the classes of Clifford circuits we propose with noise and observe exponential decays. Our theoretical results explain some of the phenomena observed in the simulations and shed light on the behavior of general linear XEB experiments.

Biography

Dr. Linghang Kong is a research scientist at Quantum Laboratory, DAMO Academy. He received his Ph.D. in physics from MIT under the supervision of Professor Aram Harrow. Before that, he received his bachelor's degree from the Institute for Interdisciplinary Information Sciences, Tsinghua University. His research interests include quantum computing architecture and quantum error correction.