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Scalable estimation of computational gate fidelities

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Scalable methods for characterizing the noise affecting a quantum system are of significant interest in theoretical and experimental quantum information theory. Since completely characterizing the noise is exponentially hard in the number of qubits comprising the system, there has been significant effort in developing scalable methods for characterizing particular features of the noise. In particular, "randomized benchmarking" has been shown to be a robust and scalable method for estimating the average error rate over the set of quantum computational gates. We propose a new protocol that allows for benchmarking individual quantum gates rather than the average over the entire set. The protocol consists of a mixture of deterministic and random applications of computational gates and is shown to be scalable in the number of qubits comprising the system. The method is robust against state preparation and measurement errors and is valid provided the average variation of the noise over the gate set can be sufficiently bounded.

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