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Learning Quantum Algorithms for NISQ Computers

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Summary

Short-depth algorithms are crucial for reducing computational error on near-term quantum computers, for which decoherence and gate infidelity remain important issues. Here we present a machine-learning approach for discovering such algorithms. We apply our method to a ubiquitous primitive: computing the overlap $\mathrm{Tr}(\rho\sigma)$ between two quantum states ρ and σ. The standard algorithm for this task, known as the Swap Test, is used in many applications such as quantum support vector machines. Here, our machine-learning approach finds algorithms that have shorter depths than the Swap Test, including one that has a constant depth (independent of problem size). Taking this as inspiration, we also present a novel constant-depth algorithm for computing the integer R\'enyi entropies, $\mathrm{Tr}(\rho^n)$, where our circuit depth is independent of both the number of qubits in ρ as well as the exponent n. These integer R\'enyi entropies are useful, e.g., for computing the entanglement spectrum for condensed matter applications. Finally, we demonstrate that both our state overlap algorithm and our R\'enyi entropy algorithm have increased robustness to noise relative to their state-of-the-art counterparts in the literature.

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