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Partially fault-tolerant quantum computing architecture with error-corrected Clifford gates and space-time efficient analog rotations

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Abstract

Quantum computers have the potential to revolutionize some computational tasks by significantly enhancing their calculation speed compared to classical computers.
Although quantum computing devices have been rapidly developed in recent years, there is still a large gap between today's noisy intermediate-scale quantum (NISQ) computing and fully fault-tolerant quantum computing (FTQC) based on quantum error correction (QEC) codes due to the very large requirements of physical qubits for the latter.
In this study, we propose a quantum computing architecture that bridges the gap between NISQ and FTQC.
This architecture realizes universal computation by noisy analog rotation gates and error-corrected Clifford gates.
Direct analog rotation is performed with small qubit requirements and residual errors are minimized by a carefully designed state injection protocol.
Our estimation based on numerical simulations shows that, for early-FTQC devices consisting of 10^4 physical qubits with physical error probability p = 10^{-4}, we can perform roughly 1.72 * 10^7 Clifford operations and 3.75 * 10^4 analog rotations on 64 logical qubits.
Such computations cannot be achieved with existing NISQ and FTQC architectures on the same device, as well as classical computers.
This talk is based on a recent paper by the authors (arXiv:2303.13181).