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tqec: A Python package for topological quantum error correction

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Summary

tqec is a Python-based open-source compiler that takes a logical-level quantum computation model represented as connected 3D primitive blocks and translates it into a detailed, fault-tolerant, physical-level circuit. The result is a `Stim` circuit with all the detailed information needed for simulation or to run on real quantum hardware. This enables both quantum algorithm designers and experimentalists to rapidly iterate and obtain exact low-level circuits, facilitating efficient performance simulation or experimental demonstration. At present, tqec is primarily centered on the surface code.

Statement of Need

Simulations of quantum computer operations in the large-scale error correction regime are currently infeasible. Building the logical `Stim` circuits is a hassle, and Monte Carlo simulations at the scale of, for example, hierarchical memory systems involving yoked surface codes, are difficult to perform exactly, C. Gidney et al. (2025). The full-scale simulations performed by tqec provide more accurate fault-tolerant resource estimation than empirical extrapolations.

tqec is designed to be used by students and researchers who seek to understand the theory of quantum error correction and experiment with scalable quantum computer system and circuit designs. A poster featuring preliminary research and an educational tutorial enabled by tqec have been approved for conference proceedings: Dubey & Smith (2025) and Kan et al. (2025) . A further software package has been recently built to enable better interfacing between PyZX and tqec: Bolanos & Fowler (n.d.). The functionality of the tqec package is based on several academic papers (Polian & Fowler (2015), Fowler et al. (2012), McEwen et al. (2023), C. Gidney et al. (2025), Kissinger & van de Wetering (2020)), and makes substantial use of Craig Gidney's `Stim` package Craig Gidney (2021).

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