Test Results: Soft-Output vs Complementary Gap

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(Dated: February 25, 2025)

I adapted the soft-output algorithm in [1] to work alongside PyMatching [2] and benchmarked the soft-output algorithm against the complementary gap method [3] by running X-memory experiments on rotated surface codes under the standard circuit-level depolarization error model with error probability $p = 10^{-3}$. It can be observed that these two methods have very similar performance.

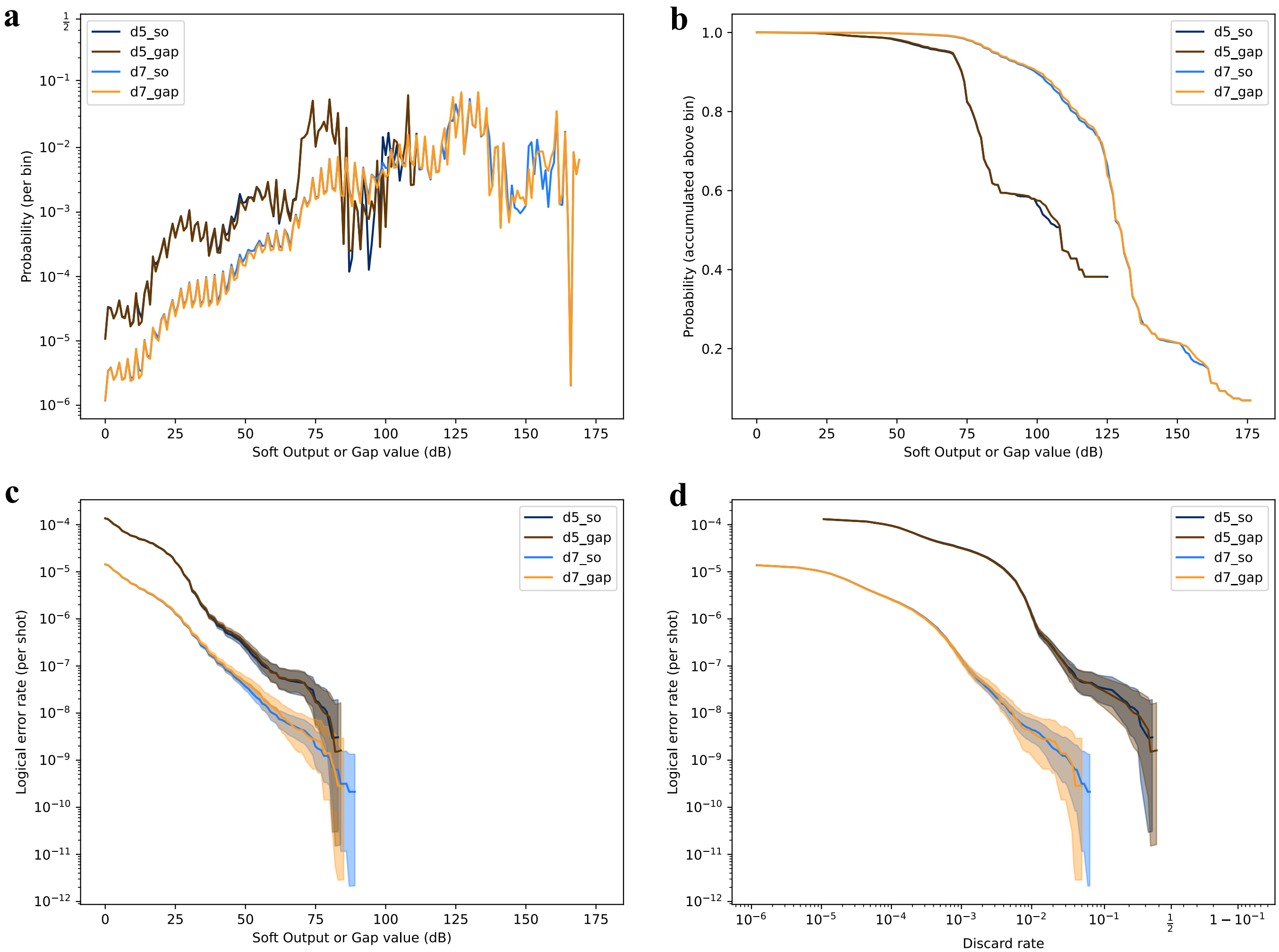

FIG. 1. Soft-output vs Complementary gap benchmarking results. The X-memory circuit used here on a rotated surface code with distance d ($d \in \{5, 7\}$) has $2d$ syndrome extraction rounds between the logical X-basis initialization and logical X-basis measurement. Both soft-outputs and complementary gaps are presented in dB and rounded to their nearest integers. (**a**) Frequency of shots at a particular soft-output/gap value. (**b**) Accumulated frequency of *all* shots *above* a particular soft-output/gap value. (**c**) Logical error rates for shots above a particular soft-output/gap value. (**d**) Trade-offs between attainable logical error rates and discard rates which measure the fraction of shots with soft-output/gap values below a specified value. Shaded regions indicate logical error rate hypotheses whose likelihood is within a factor 1000 of the maximum likelihood. The estimated logical error rates for the complementary gap method with $d = 7$ have slightly larger uncertainty than the soft-output results, which is the result of fewer shots taken for testing the complementary gap method. The soft-output method is also highly efficient and is about 2× faster than the complementary gap method for the benchmarkings above.

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[1] N. Meister, C. A. Pattison, and J. Preskill, Efficient soft-output decoders for the surface code (2024), arXiv:2405.07433.
[2] O. Higgott and C. Gidney, Sparse Blossom: correcting a million errors per core second with minimum-weight matching (2025), arXiv:2303.15933.
[3] C. Gidney, M. Newman, P. Brooks, and C. Jones, Yoked surface codes (2023), arXiv:2312.04522.