THE UNIVERSITY OF CHICAGO

Computational and Applied Mathematics & Statistics Student Seminar

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BOLT: Block-Orthonormal Lanczos for Trace Estimation of Matrix Functions

Wednesday, December 3, 2025
12:30 PM
DSI, 5460 S University Ave,
Room 105, Chicago, IL 60615

ABSTRACT

Efficient matrix trace estimation is essential for scalable computation of log-determinants, matrix norms, and distributional divergences. In many large-scale applications, the matrices involved are too large to store or access in full, making even a single matrix–vector (mat–vec) product infeasible. Instead, one often has access only to small subblocks of the matrix or localized matrix–vector products on restricted index sets. Hutch achieves optimal convergence rate but relies on randomized SVD and assumes full mat–vec access, making it difficult to apply in these constrained settings. We propose the Block-Orthonormal Stochastic Lanczos Quadrature (BOLT), which outperforms Hutch++ in near flat-spectrum settings while maintaining a simpler implementation based on orthonormal block probes and Lanczos iterations. BOLT builds on the Stochastic Lanczos Quadrature (SLQ) framework, which combines random probing with Krylov subspace methods to efficiently approximate traces of matrix functions. To address memory limitations and partial access constraints, we introduce Subblock SLQ, a variant of BOLT that operates only on small principal submatrices. As a result, this framework yields a proxy KL divergence estimator and an efficient method for computing the Wasserstein-2 distance between Gaussians—both compatible with low-memory and partial-access regimes. We provide theoretical guarantees and demonstrate strong empirical performance across a range of high-dimensional settings.

Corresponding paper link: https://arxiv.org/pdf/2505.12289