NFFT meets Krylov methods: Fast matrix-vector products for the graph Laplacian of fully connected networks.

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The graph Laplacian is a standard tool in data science, machine learning, and image processing. The corresponding matrix inherits the complex structure of the underlying network and is densely populated in certain applications. A typical task is the computation of a number of its eigenvalues and eigenvectors.

Standard methods become infeasible as the number of nodes and edges in the graph is too large. We propose to use Krylov subspace methods in combination with a fast summation approach based on the nonequispaced fast Fourier transform (NFFT) to perform dense matrix-vector products with the graph Laplacian in a fast way. The enormous flexibility of the NFFT algorithm allows us to embed the accelerated matrix-vector multiplication into Lanczos-based eigenvalues routines and iterative linear system solvers.

We illustrate the feasibility and advantages of our approach on several numerical examples. In particular, we compare our approach with the Nyström method.