

Reference Free Cryo-EM Structure Determination through Eigenvectors of Sparse Matrices

We describe a spectral graph algorithm for reconstructing the three-dimensional structure of molecules from their Cryo-EM images taken at random unknown orientations. The key idea of the algorithm is designing a sparse operator defined on the projection data, whose eigenvectors reveal the orientation of each projection. Such an operator is constructed by utilizing the geometry induced on Fourier space by the projection-slice theorem. The presented algorithm is direct (as opposed to iterative refinement schemes), does not require any prior model for the reconstructed object, and shown to have favorable computational and numerical properties. Moreover, our algorithm does not impose any assumption on the distribution of the projection orientations. Physically, this means that the algorithm successfully reconstructs molecules that have unknown spatial preference.

No prior knowledge of tomography, electron microscopy, or spectral graph theory is assumed.

This is a joint work with Amit Singer, Ronald Coifman, and Fred Sigworth (Yale University).