Estimation of orientations and deformations from non-oriented tomographic projections

Laboratory

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key-words tomography, dimension reduction, electron microscopy, three-dimensional reconstruction macromolecule

Tuition fees : available in the RHODES project.
textit Continuation possible in PhD under RHODES project.

General frame

This internship subject is part of the RHODES project on tomography applied to electron microscopy with the objective of improving methods for spatial reconstruction of protein in molecular biology (Figure 1).

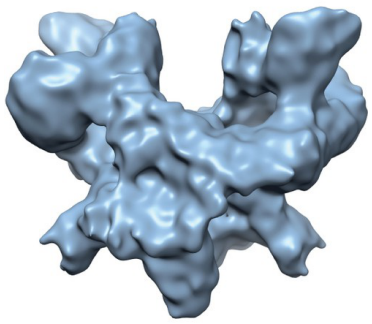

FIGURE 1 – Examples of 3D objects rebuild (TAF4 protein) [P.Schultz]

Scientific positioning and objectives

Tomography allows to reconstruct an object (2D or 3D) from a set of projections of the object from different angles. It is mainly used in medical scanners. In this case, the angle corresponding to each projection is known and used for the reconstruction of the object. In some applications (including cryo-electron tomography), projections are acquired without information on the corresponding projection angles. This case has been studied extensively without leading to a universal solution. In particular, reconstruction of deformable objects is the subject of active research (including in the team *Architecture nucleoprotein systems by electron microscopy 3-D* of P.Schultz, IGBMC, with which it collaborates). This is an important issue because many objects being studied tomography are actually deformable. For tomography where projections are oriented is well treated, but the cases (which interests us) when their orientations are unknown currently treated by refinement from a first recontruction of the object [LN07].

We propose to use a dimension reduction to estimate the angle and deformation parameters (see figure 2).

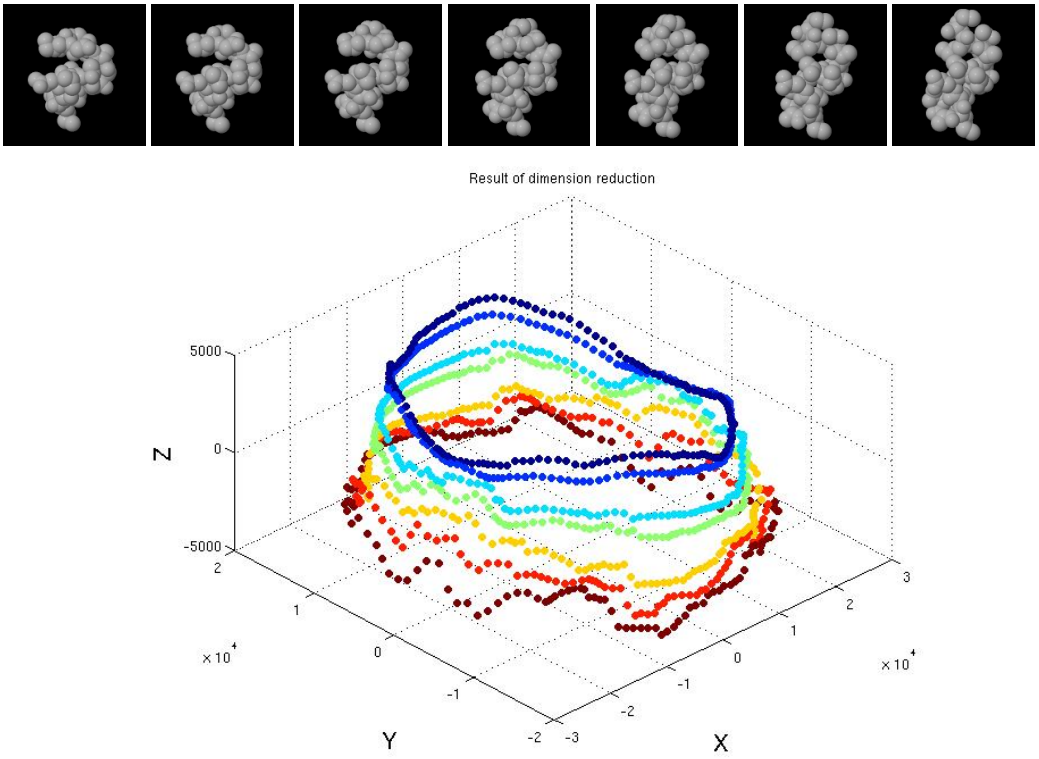

FIGURE 2 – Top : sampling a continuous deformation in 7 states of a macromolecule represented in 2D. Bottom : Results of dimension reduction (dimensions 1.2 and 7) performed directly on the projections of the 2D object (150 for each of the above statements). The colors are artificial and indicate membership in one of the 7 conformations. This result is a basis for estimating directions and conformational states without allowing estimate directly.

two steps are necessary

1. estimating the geodesic distance between the projections and the main geodesic dimensions,
2. parameterization and projections in the reduced space.

The estimation of orientations based on dimension reduction has been studied by Singer and Wu [SW13] in the 2D noisy case. However, the case with the 3D or with deformation is not yet treated. This is the purpose of this internship.

The work consists initially in a study of the different estimates of the geodesic distance and their robustness, and then to perform the parameterization of projections, including the information on the projection-set geometry.

Proposed work plan

— literature review ;
— Study of the geodesic distance in 2D ;
— influence of the sampling on the dimension reduction ;
— parameterization of projections ;
— testing and validation (different image sizes) ;
— noise robustness
— 3D case ;
— report writing.

Compétences souhaitées

— Mathematical basis.
— Programming skills (C, matlab) and optimization.
— Autonomy and initiative.

Contact us for more information.

Références

[LN07] A. E. LESCHZINER et E. NOGALES : Visualizing flexibility at molecular resolution : Analysis of heterogeneity in single-particle electron microscopy reconstructions. *Annu. Rev. Biophys. Biomol. Struct.*, 36:pp 43–62, 2007.

[SW13] A. SINGER et H. WU : Two-dimensional tomography from noisy projections taken at unknown random directions. *SIAM J Imaging Sc*, 6(1):136–175, 2013.