PhD Thesis

Tomographic reconstruction of deformable objects

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Background

This thesis is funded RHODES project RHODES on the tomography applied to electron microscopy with the objective of improving methods for spatial reconstruction in molecular biology proteins. Tomography allows to reconstruct an object (2D or 3D) from a set of projections of this object taken different orientations.

In our case, we call projection of a function with positive values in a direction, all the integral values following all collinear straight lines to this direction.

The thesis will focus on the development of statistical methods for the reconstruction of all the states of a deformable 3D object from its 2D tomographic projections. Two strong assumptions determine that reconstruction : 1) direction and the state corresponding to each projection are unknown 2) significant noise is present on the projections.

We are interested in this work in case all states come from a continuous deformation of the object. In this case, we propose to use methods of dimension reduction to estimate the orientations of the projections and the parameters of the deformation.

Estimating orientations with dimension reduction has been studied by Singer and Wu [SW13] in case 2D noisy. However the case of continuous deformations is not currently addressed in the literature and is part of this PhD subject. The macromolecule having a continuous deformation is seen as a deformable object.

Scientific Goal

In a first step, the goal is to obtain a representation of the projection of images by a set of points in a low dimensional space. For this, we will build on the PhD work of Phan MS [PBMT14] and the internship report of Z. Zouch. The next step is to estimate the direction and deformation parameters. Secondly, we will focus on the reconstruction of nD object (n<5) formed by all the conformations of the molecule. This study will be done first on synthetic data and on real data.

Proposed Work Plan

- Bibliographic study ;
- 2D deformable Case
  - Influence of sampling on dimension reduction ;
  - Parameterization of projections ;
  - Testing and validation (different image sizes) ;
  - Robustness to noise ;
- 3D case ;
  - Rigid case
  - Deformable case ;
- Reconstruction in the case deformable.

Skills required

This thesis addresses a student holds a Master 2 (or engineering degree) in mathematics/Computer Science

Application

Send your application to Etienne Baudrier baudrier@unistra.fr providing a CV, academic results of last year (ranked if possible), a letter of recommendation and possibly the contact with teachers who have mentored you.

Références

[PBMT14] M. Phan, É. Baudrier, L. Mazo, and M. Tajine. Angular difference measure between tomographic projections taken at unknown directions in 2d. In *Int Conf Image Process 2014*. IEEE, Oct 2014.

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