PhD Thesis

# Tomographic reconstruction of deformable objects for single particle electron microscopy

**Advisors**

- Mohamed TAJINE (director)
- Étienne BAUDRIER
- Loïc Mazo

## Host laboratory

Team MIV
ICube (UMR 7357) CNRS-UdS
Parc d'Innovation,
Boulevard Sébastien Brant, BP 10413,
67412 Illkirch Cedex

**Keywords** : dimension reduction, tomographic reconstruction, deformation

## Cadre général

This PhD project is funded RHODES on applied tomography electron microscopy with the objective of improving methods for spatial reconstruction in molecular biology proteins (see Figure **??**). The tomography can reconstruct a 2D or 3D object from a set of its projections in different orientations. It is used in particular in medical scanners. In this case, the orientation corresponding to each projection is known and used for the reconstruction of the object. In some applications (including electron microscopy), the projections are obtained without information on the orientations of the corresponding projections. However, these projection orientations are an information without which reconstruction is impossible. The search of the orientations of projection represents an important step and it has been extensively studied without leading to a universal solution. In particular, the reconstruction of a deformable object is an active research field. This is a major issue because many objects being studied by tomography are actually deformable (see Fig 1). This takes place in particular in the field of cryo-electron microscopy

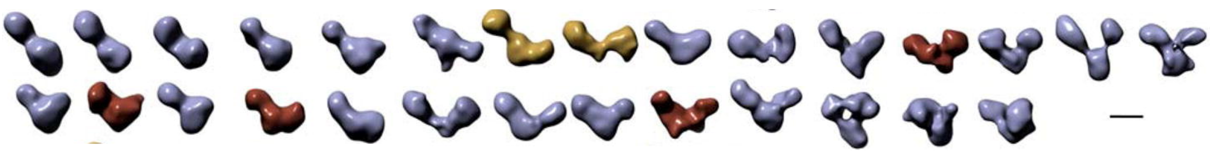

FIGURE 1 – Macromolecule TFIID in several conformations [P.Schultz]

which aims to reconstruct the three-dimensional structure of macromolecules.

The case of projections with known angles has been already well treated, but the case where the directions are not known is still open. Especially, the case of continuous deformations is not currently addressed in the literature and it is part of this thesis. The macromolecule having a continuous deformation is seen as a deformable object. As a first step, the goal is to obtain a representation of the images of projection by a set of points in a low dimensional space. Then, it is expected to estimate the direction and parameters of the projection images. In a second step, we will focus on the reconstruction of the object formed by the molecule together with its deformation. This study will be made initially on synthetic data, then on the real data.

The estimated orientations dimension reduction has been studied by Singer and Wu [SW13] in the 2D noisy case. But the case of continuous deformations is not currently addressed in the literature and it is part of this thesis. The macromolecule having a continuous deformation is seen as an deformable object.

### Scientific objective

Firstly, the goal is to obtain a representation of the projection images by a point set in a low dimensional space. For this, the study will be based on MS Phan's PhD thesis [PBMT14] and the report of Z. Zouch. The next step is to estimate the direction and parameters of the projection images. Secondly, we will focus on the reconstruction of the object formed by the molecule by deforming. This study will be done first on synthetic data, then the real data.

### Plan de travail proposé

- Bibliographic study ;
- deformable 2D 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.

### Desired skills

This thesis addresses a student holding a Master 2 (or engineering degree) in applied mathematics with an interest in computer science or computer science with strong mathematical basis.

### Application

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

**Net pay :** 1550 euros/mth

## 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.