Deformable Meshes for Tomographic Reconstruction and Segmentation

Jakeoung Koo, jakoo@dtu.dk
Vedrana Andersen Dahl, Anders Bjorholm Dahl
Department of Applied Mathematics and Computer Science
Technical University of Denmark, Anker Engelunds Vej 1, Kgs. Lyngby 2800, Denmark

Introduction

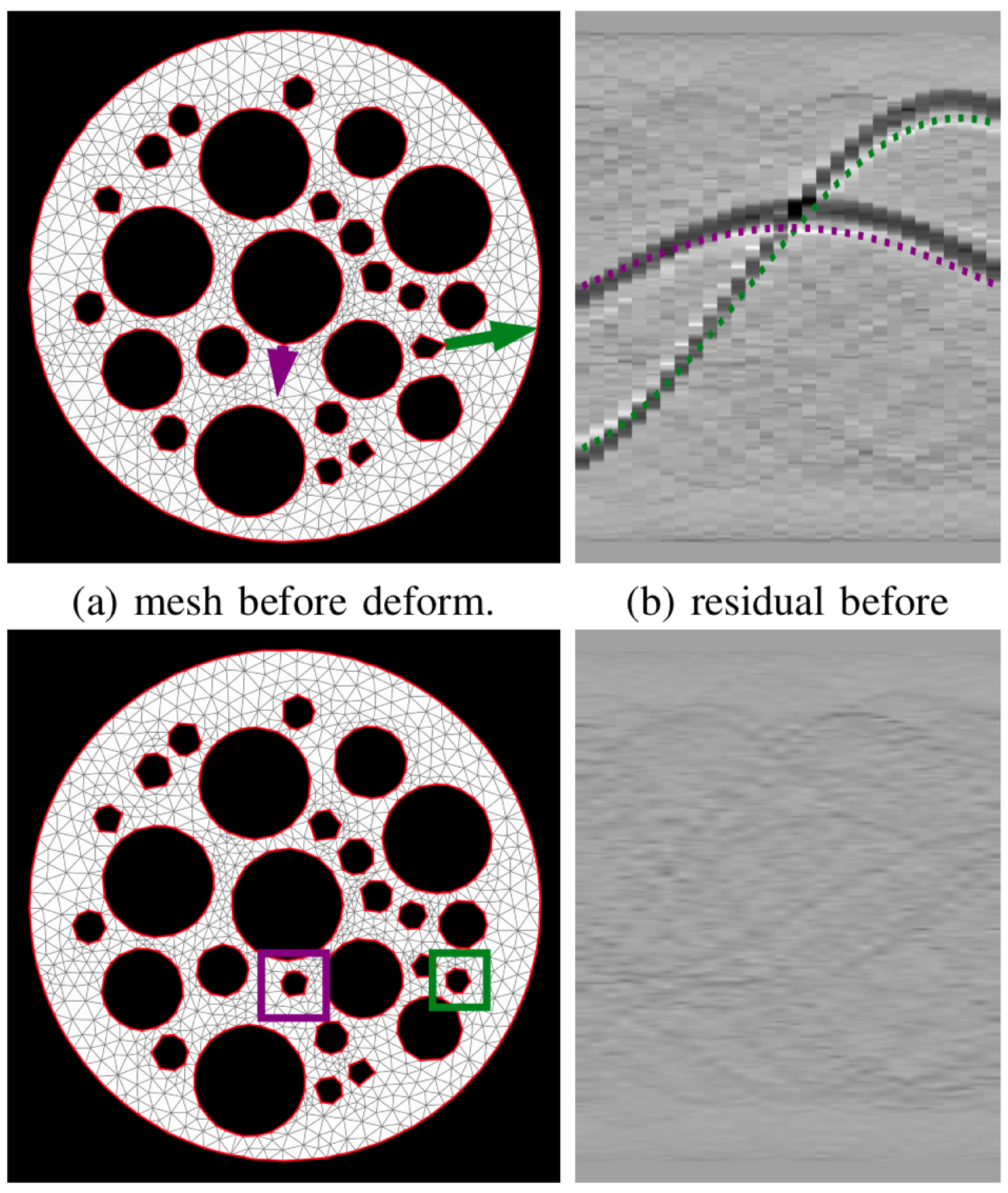
Problem definition: Tomographic reconstruction and segmentation

- Input: projections (sinogram), e.g., from X-ray.
- Output: outline of the scanned object (by curves)

Abstract. We suggest a method for tomographic reconstruction based on a deformable mesh. Our method provides a reconstruction with piece-wise constant attenuation coefficients and allows for topological adaptivity, such that separated objects with the same attenuation can be accurately reconstructed. Since these regions have the same attenuation, the obtained reconstruction is also a segmentation.

Our approach

- Represent the object based on mesh: each face is labeled as one material. An outline of an object is defined as the edges in a mesh whose two faces have different labels.
- Initialize the mesh based on filtered backprojection or graph total variation.
- Deform the mesh [2] to align with object boundaries in the direction of minimizing the energy:



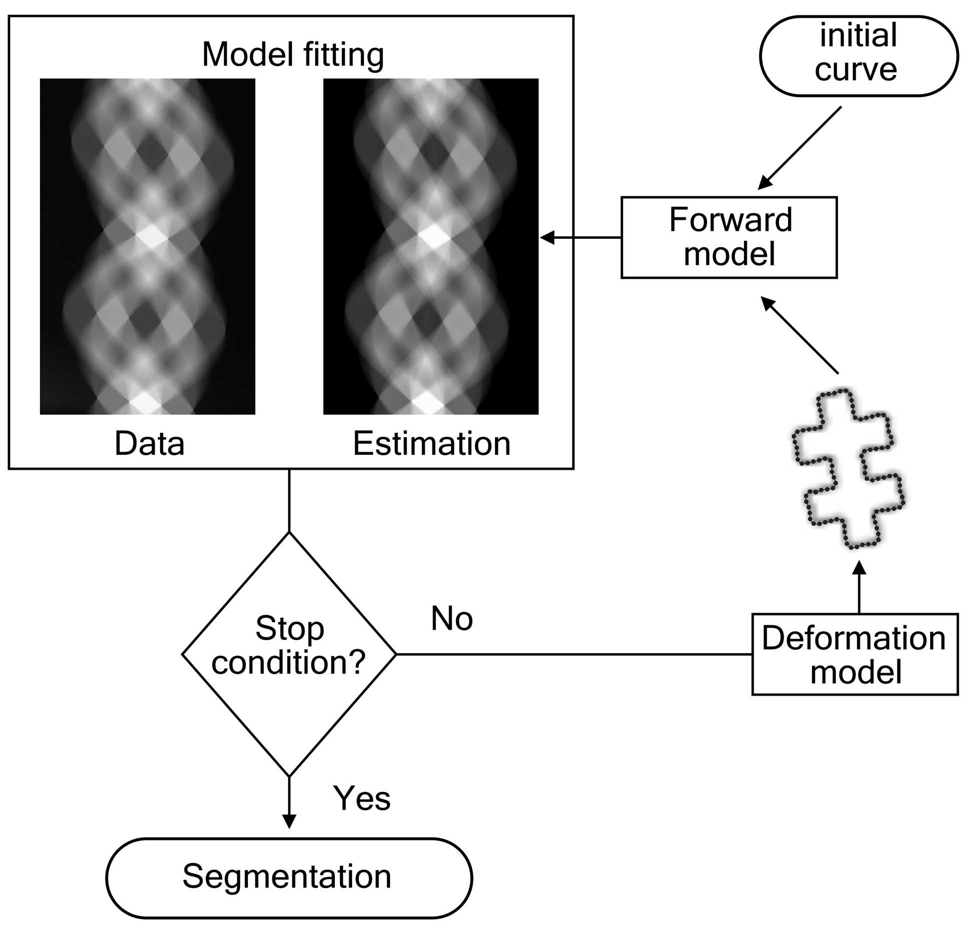
(a) mesh before deform. (b) residual before
(c) mesh after deform. (d) residual after

Energy formulation

The objects of interest are assumed to have a constant attenuation coefficients.

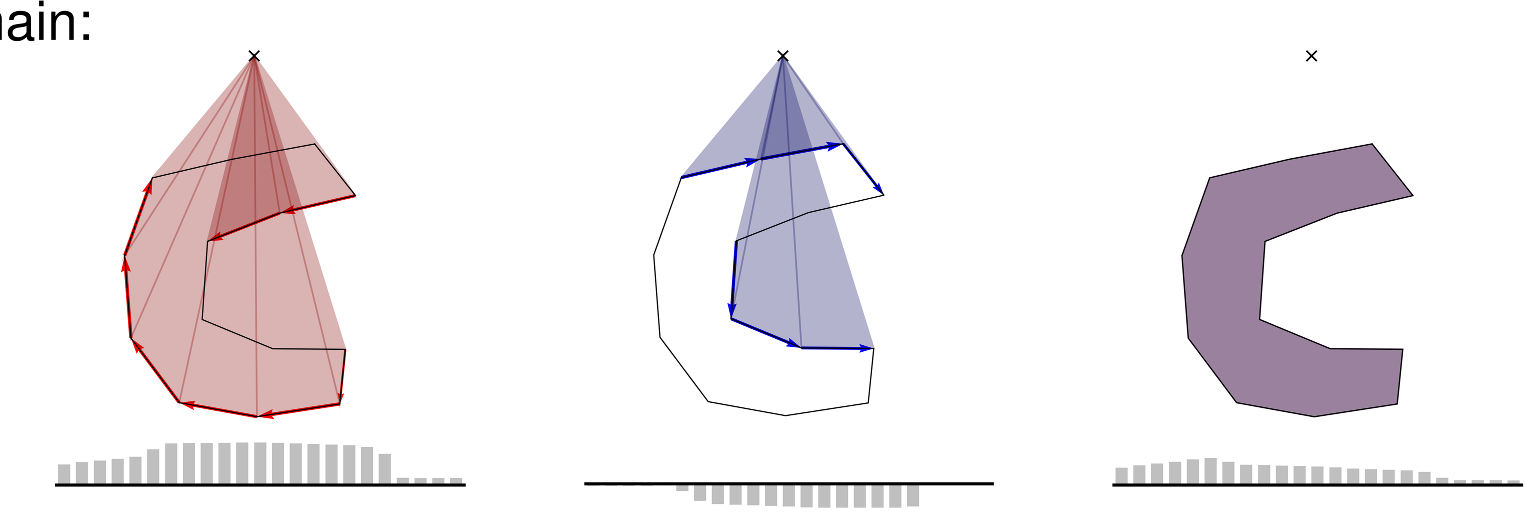
$$\min E(C,\mu) = \sum_{\theta,s} (p(\theta,s) - \mu\hat{p}(\theta,s))^2 + R(C)$$

- p: sinogram data
- $\hat{p}$: estimated sinogram by our forward projection
- μ : Attenuation coefficient (is assumed to be constant)
- R: regularization (we choose curve length)



Optimization

Forward model The forward model transforms the curve into sinogram domain:



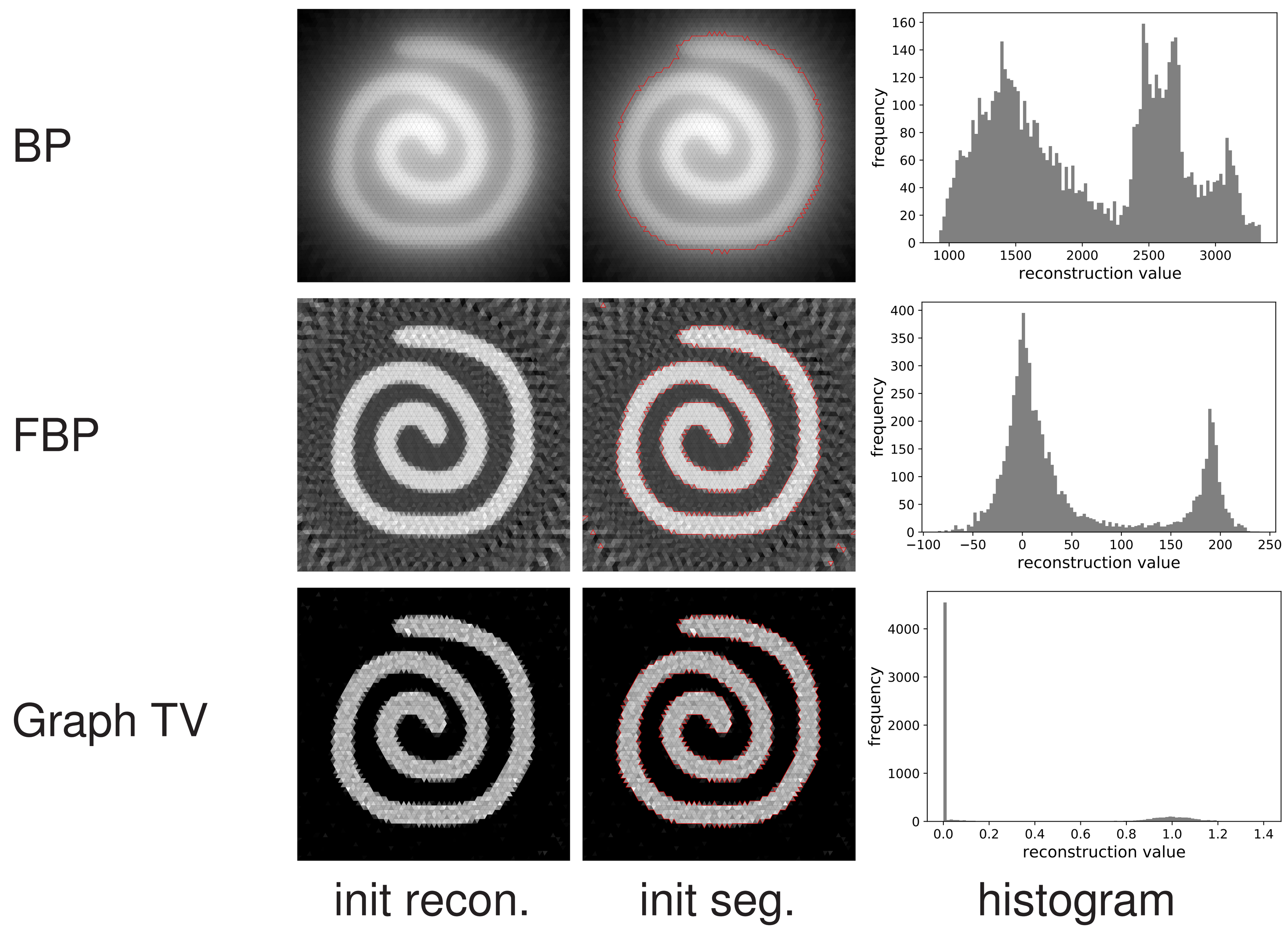
Attenuation coefficient. Optimize the energy with respect to μ.

Curve deformation. Optimize the energy with respect to the curve:

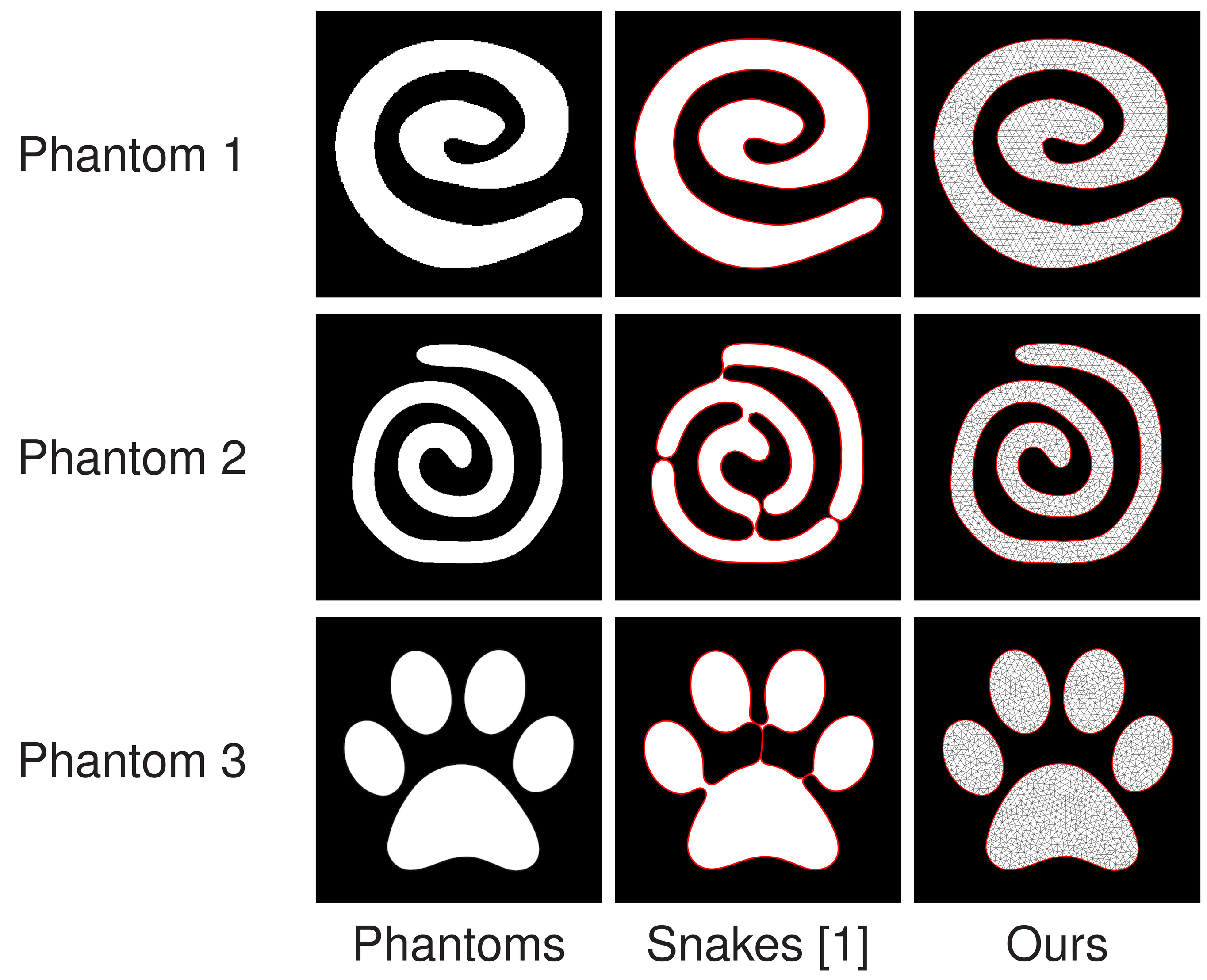
$$C_t = \tau(\mu \sum_{\theta} (p - \mu\hat{p}) + \lambda\kappa)\mathcal{N}$$

where $\mathcal{N}$ represents the outward unit normal vector, τ the step size and κ the curvature.

Initialization



Ours supports topological changes



Reference and Acknowledgement

[1] V. A. Dahl, A. B. Dahl, and P. C. Hansen, "Computing segmentations directly from x-ray projection data via parametric deformable curves," Meas. Sci. Technol. 2018.

[2] M. K. Misztal and J. A. Bærentzen, "Topology-adaptive interface tracking using the deformable simplicial complex," TOG 2012.

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