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Modular Multi-Shape Registration

collaboration with
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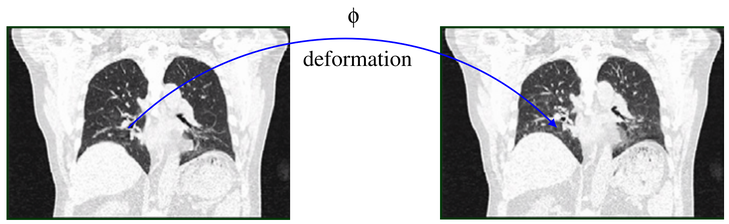
The Registration Problem

An important question in medical image analysis is the comparison of images. It can help to model tumor growth or to improve interventions. Image Registration aims to model this problem mathematically.



Source image I_S Target image I_T

To build a plausible transformation, our model incorporates prior knowledge on the represented objects.

Images taken from www.dir-lab.com

Contributions

The new framework can model prior knowledge on deformations of different organs and tissues, combined with object-boundary constraints.

Theoretical Results
Existence of minimisers
Derivation of geodesic equations

Numerical Results
Evaluation on synthetic data

In practice: Solving the optimisation problem

$$\min_{\phi} \underbrace{\int_0^1 \mathcal{R}(\phi_t)\mathrm{d}t}_{\textit{Plausibility}} + \underbrace{\mathcal{U}(I_S \circ \phi_1^{-1}, I_T)}_{\textit{Similarity}}$$

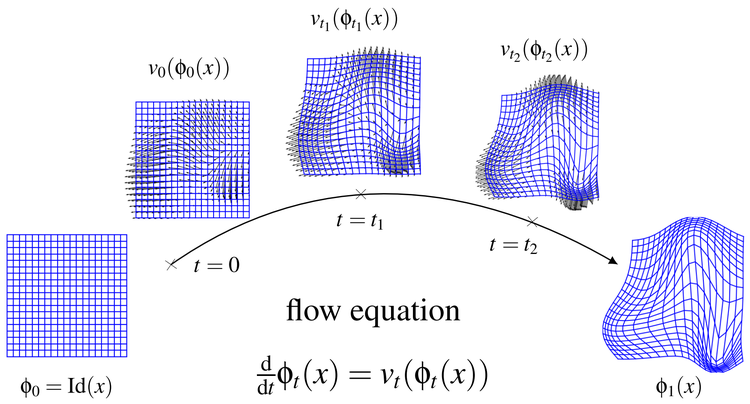
$$s.t. \quad \text{flow equation}, \quad \text{initial condition}, \quad \text{boundary constraints}$$

determined by the deformation module

Multi-Shape boundary constraints

Deformations as flows

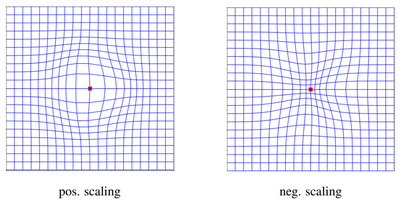
Deformation is modeled as a flow of vectorfields v_t, giving the speed at every point, over time. This ensures diffeomorphisms, which are topology preserving and therefore prevent holes or foldings.



Beg, et al. (2005). Computing large deformation metric mappings via geodesic flows of diffeomorphisms.

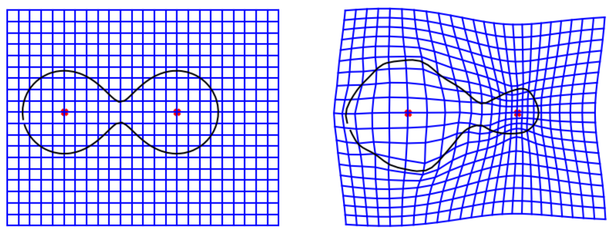
Deformation Modules

Deformation modules provide a framework of building deformations satisfying a certain desired structure.



pos. scaling neg. scaling

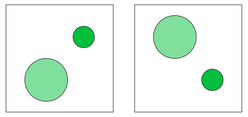
Example: Local Scalings
Local Scalings at different centers of different amounts can be obtained by the same deformation module. The scaling is defined by the center (red cross) and a real number giving the amount of scaling.



Example deformation of two combined scalings.

Gris (2016). Modular approach on shape spaces, Sub-Riemannian geometry and computational anatomy.

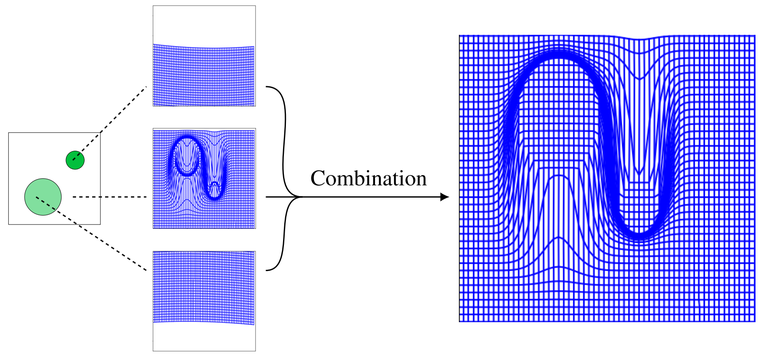
Multi-Shape Registration



source target

The translation of two circles (upwards for the bigger circle, downwards for the lower circle) should be modeled seperately, with the background deformation being consistent at the boundaries.

The deformations are built for each shape and then combined to built the multi-shape deformation.



Arguillère (2014). Géométrie sous-riemannienne en dimension infinie et applications à l'analyse mathématique des formes.

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