Scientific Computing Seminar

Image Registration using Large Deformations Diffeomorphic Metric Mapping (LDDMM)

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Abstract: Image registration is a key task in image analysis. Its applications range from fusing multimodal data over object tracking to motion modeling, e.g. for the respiratory system. In the latter example large motions occur and inside the lungs no foldings of tissue are to be expected. Hence it is appropriate to model the movement as a diffeomorphic nonlinear trans- formation. As requirements like diffeomorphic transformations and the capability of capturing large motions are often necessary in image registration the Large Deformations Diffeomorphic Metric Mapping (LDDMM) approach is very useful.

The theoretical foundations for LDDMM were laid in the late 1990s and the beginning of the 2000s by Grenander, Christensen, Miller, Trouve, Younes and others. In 2005 Beg et al. [1] provided a practical algorithm to solve the LDDMM image registration problem. LDDMM is related to optical flow. In [2] optical flow problems were solved using an optimal control approach. Following a similar approach in 2009 the LDDMM model was used for image registration from an optimal control perspective in [3].

In the talk I will give an introduction to LDDMM following loosely [3] and start with the matching of scalars, which results in a tool for linear regression. In this example, the two different concepts of relaxation and shooting are illustrated. In the relaxation approach the optimization is performed regarding the complete temporal velocity field. However, in the shooting approach the optimization is only over the initial condition, i.e., slope and possibly y-intercept of the line. I will then discuss how to extend these ideas to the problem of image matching and how to discretize the optimization problem using consistent Runge-Kutta methods for the transport equation and its adjoint.

References

[1] Mirza Faisal Beg, Michael I. Miller, Alain Trouve, and Laurent Younes. Computing large deformation metric mappings via geodesic flows of diffeomorphisms. International Journal of Computer Vision, 61(2):139157, 2005.

[2] Alfio Borzi, Kazufumi Ito, and Karl Kunisch. Optimal Control Formulation for Determining Optical Flow. SIAM Journal on Scientific Computing, 24(3):818847, 2003.

[3] Gabriel L. Hart, Christopher Zach, and Marc Niethammer. An optimal control approach for deformable registration. 2009 IEEE Computer Society Conference on Computer Vision and Pattern Recognition Workshops, 2(1), 2009.

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