Post-Doctoral position
Optimal Image Transport; Application to Dynamic Medical Image Analysis

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Context
Current medical imaging techniques allow the analysis of the anatomy and of several functions of human being. The context of this project concerns the joint exploitation of complementary cardiac examinations for the analysis of the normal and pathological cardiac dynamics. The objective is to rationally integrate anatomical, structural (e.g. cardiac fibre architecture), tissue properties (e.g. necrosis) and motion data into a subject specific model. Due to the sparse (in 3D space and time) and possibly noisy nature of the data, constrained spatio-temporal (3D+time) methods with *a priori* integration are required.
The *3DStrain* ANR project (2011-2015), which gathers 4 institutional partners and one company, is focused on this theme namely the recovery of shape and motion from multimodality cardiac imaging (see the project web site: here). The post-doctoral project is financed for two years in this context. The research developments will be conducted in collaboration between ICJ Laboratory (CNRS UMR 5208) and CREATIS Laboratory (CNRS UMR 5220, Inserm U1044).

Objective
The post-doctoral project consists in the development of optimal transport methods for estimating motion in image sequences. Such an approach allows determining velocity without inclusion of arbitrary regularisation terms. This theoretical framework is a very active and competitive field at the international level. Let us mention for instance the work of Haker and Tannenbaum [1], Miller et al. [2], Keeling et al. [3], Rehman et al. [4] and the book of Villani [5].

More precisely, given an image series of an moving object at discrete time $t1$, $t2$ . . . tf, we aim at reconstruct the motion at any time $t \in [t1; tf]$. The work will consist in:

- The mathematical formulation of the problem within the optimal transport framework. To this aim, the recent results established in [6]-[11] will be exploited.

- The introduction of additional information in the form of constraints: prescribed position of specific points (e.g. landmarks), privileged orientations …

- The implementation of the proposed method and its experiment for the estimation of the cardiac motion from dynamic multimodality examinations (MRI, Ultrasound, CT) in collaboration with the 3DStrain project partners. The developed methods will be evaluated on a databases constituted of normal and pathological cases in the context of the project. They will be integrated within the computer platforms used in the group and the 3DStrain project.

Competences: applied mathematics: PDE, numerical analysis, scientific computation; signal and image processing.
The post-doctoral student will collaborate with a multidisciplinary group composed of mathematicians, computer scientists, specialists in image processing and physicians.

Conditions
Salary: 4000euros gross/month
Duration: 1-year renewable 1 year

References

[1] S. Haker and A. Tannenbaum. On the Monge-Kantorovich problem and image warping. *Mathematical methods in computer vision, IMA Vol. Math. Appl., 133*, pages 65–85, 2003.

[2] M. Miller, A. Trouvé and L. Younès. Geodesic shooting for computational anatomy. Jour. *Math. Imaging , Vol. 24*, pages 209–228, 2006.

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[5] C. Villani, "Optimal transport old and new", Comprehensive studies in mathematics 338, Springer-Verlag, 2009.

References of the group

[6] O. Besson and J. Pousin. Solution for linear conservation laws with velocity field in *l1*. *Archive of Ration. Mech. and Ana.*, 186(1) :159–175, 2007.

[7] J. Schaerer, C. Casta, J. Pousin, and P. Clarysse, "A dynamic elastic model for segmentation and tracking of the heart in MR image sequences " *Medical Image Analysis*, vol. 14, pp. 738-749, 2010.

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[9] M. Picq J. Pousin, "Resolution of the transport equation subject to constraint". *Journal of Computational and Applied Mathematics*, 218, vol. 2, pp. 364-375, 2008

[10] P. Clarysse, B. Delhay, M. Picq, and J. Pousin, "Optimal extended optical flow subject to a statistical constraint," *Journal of Computational and Applied Mathematics*, vol. 234, pp. 1291-1302, Jun 15 2010.

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