Parallel transport for cardiac motion modeling: exploration of relative volume-preserving strategies

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In this talk, I will apply the tools developed in Lorenzi et al. 2014; Guigui et al. 2021 to the study of the motion of the cardiac right ventricle under pressure or volume overload. The difficulty of this task lies in the interactions between shape and deformation. The central idea of this work is to filter out these interactions using the parallel transport of deformations to a reference shape, where deformations are considered in the Large Deformations Diffeomorphic Metric Mapping (LDDMM) framework. It appears that parallel transport alone is not sufficient to normalize deformations when large volume differences occur. We thus propose a normalization procedure for the amplitude of the deformation, and compare it with volume-preserving metrics. After normalization, we use a geodesic regression to represent the full cardiac contraction. The statistical analysis of the parameters of the model reveal insights into the dynamics of each disease. The method is applied to 3D meshes of the right ventricle extracted from echocardiographic sequences of 314 patients divided into three disease categories and a control group (Moceri et al. 2018).

Joint work with: Xavier Pennec, Pamela Moceri, Nicolas Duchateau.

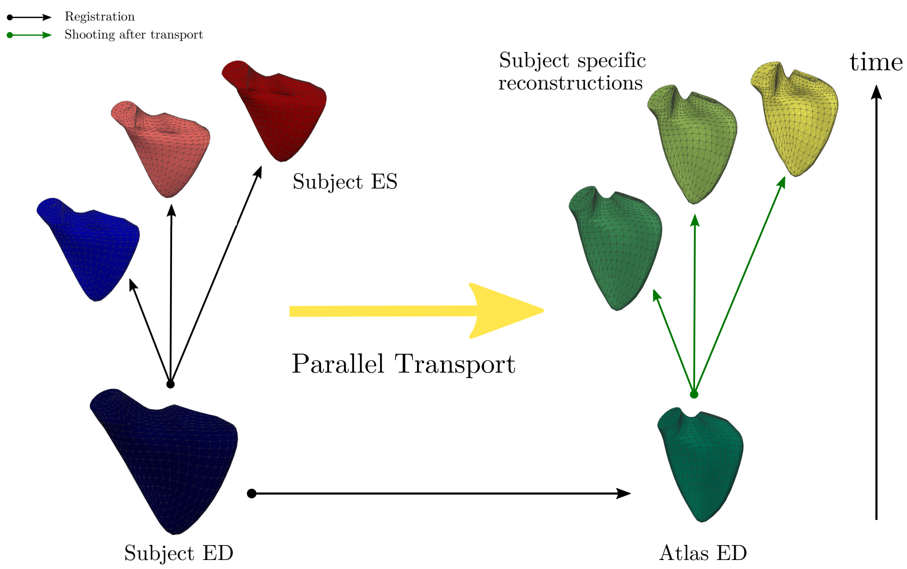

Figure 1: Our framework to normalize cardiac deformations: we rely on registration to estimate deformations, and parallel transport to normalize them.

References

Guigui, Nicolas and Xavier Pennec (June 2021). "Numerical Accuracy of Ladder Schemes for Parallel Transport on Manifolds". In: *Foundations of Computational Mathematics*. ISSN: 1615-3383. DOI: 10.1007/s10208-021-09515-x.

Lorenzi, Marco and Xavier Pennec (Sept. 2014). "Efficient Parallel Transport of Deformations in Time Series of Images: From Schild to Pole Ladder". In: *Journal of Mathematical Imaging and Vision* 50.1, pp. 5–17. ISSN: 1573-7683. DOI: 10.1007/s10851-013-0470-3.

Moceri, Pamela, Nicolas Duchateau, Delphine Baudouy, Elie-Dan Schouver, Sylvie Leroy, et al. (Apr. 2018). "Three-Dimensional Right-Ventricular Regional Deformation and Survival in Pulmonary Hypertension". In: *European Heart Journal - Cardiovascular Imaging* 19.4, pp. 450–458. ISSN: 2047-2404. DOI: 10.1093/ehjci/jex163.