Variability Analysis of Heart Fiber Orientation Using Diffusion Tensor MRI

Sylvain Jaume, Hervé Delingette, Nicholas Ayache

{Sylvain.Jaume, Herve.Delingette, Nicholas.Ayache}@sophia.inria.fr

Abstract. The fiber orientation in the heart could influence both its mechanical and electrical operations. Measuring a small variability would indicate that an a priori model of the fibers would be suitable for different subjects. We propose to analyze the fiber orientation in Diffusion Tensor (DT) MRI for five ex-vivo canine hearts using 3D parameterization and local fiber registration.

1 Introduction

To observe the heart fibers, Holmes et al. [1] show consistent results between histological analysis and DT-MRI. Geerts et al. [2] characterize the fiber orientation in DT-MRI for a goat heart. Recently Helm [3] has proposed an analysis across five DT-MRI scans based a registration for large deformations.

2 Method

We propose to parameterize the five scans acquired by Helm et al. based on an extension of the American Heart Association segmentation. We then apply a local registration to the fiber directions, and finally visualize the covariance of the registered directions in the volume of the heart.

2.1 Landmarks and parameterization

Figure 1 indicates the American Heart Association regions for the left ventricle and the regions that we define for the right ventricle. An expert places the landmarks in the highest slice and the lowest slice where the epicard and both ventricles are visible. The heart is vertically positionned in the scanner, and thus the slices are orthogonal to the heart axis in every scan.

2.2 Registration and statistics

Figure 2 demonstrates in the left image that the fiber directions for one parameterized heart are registered to the anatomy of a reference heart. In the right image, the covariance matrix of the fiber orientation is visualized at every point using an ellipsoid. The axes and the color of the ellipsoids correspond to the eigenvectors and to the trace of the matrix respectively.

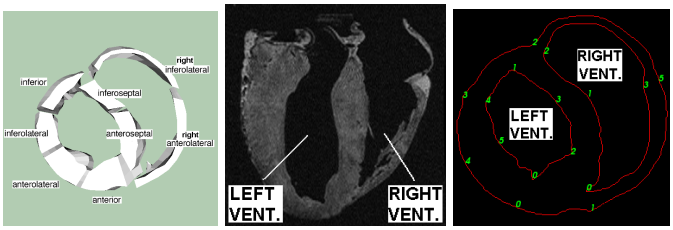

Fig. 1. The landmarks placed in five MRI scans extend the recommendations of the American Heart Association *(left)*. The T1 MRI scans *(middle)* image the anatomy of the heart, and the DT-MRI allows the reconstruction of the fiber directions. For every scan, an expert places the landmarks in the top slice *(right)* and in the bottom slice.

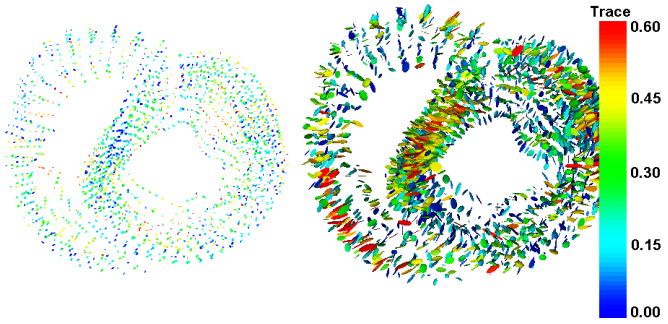

Fig. 2. The fibers of every heart are registered to a reference heart *(left)* and the covariance of their orientation is then computed across the five hearts. The ellipsoids *(right)* are oriented in the directions of highest variability (eigenvectors of the covariance matrix), and color coded from low (blue) to high (red) variability.

3 Results and Discussion

Figure 2 shows that the variability for the fiber orientation is relatively small in most regions of the heart. A larger number of scans including human hearts and a comparison with an histological study would validate that an a priori model of the fibers could be used for different anatomies.

References

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