**Groupwise Registration and Diffusion Tensor Reorientation in Cardiac MRI: Application to Explanted Porcine Hearts**

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**Introduction:** Cardiovascular diseases (CVDs) are the leading cause of mortality worldwide, accounting annually for over 15 million deaths. Image-based models and statistical atlases of the cardiac anatomy and physiology can aid in better diagnosis and treatment planning of CVD. In this abstract, we propose a framework for constructing a myocardial statistical atlas from *ex vivo* diffusion tensor images (DTI) of porcine hearts (with size comparable to human hearts), by first computing an average geometry and then obtaining directional information of diffusion linked to the reference frame of the transformed subjects.

**Methods:** All high resolution DT MR images were acquired on a 1.5T GE Signa Excite scanner in freshly explanted healthy pig hearts (N = 4) at sub-millimetric resolution, by using the following MR parameters: TE = 35 ms, TR = 700 ms, echo train length = 2, b-value = 0 for the unweighted MR images and b = 500 s/mm$^2$ for the seven diffusion gradients, respectively [2]. Notably, the total MR imaging time is ~10 hours/heart, which is not feasible for *in vivo* patient studies. An average geometry was computed by performing groupwise registration on the 3D anatomical images. At every iteration, the reference geometry was updated using an averaging technique that takes into account all the transformations aligning each subject to the current reference geometry. The said transformations were obtained through multilevel affine and nonparametric registration. This scheme normalizes the cardiac geometries of the anatomical MR images despite a high variability in their measurements. Once the transformations aligning the subjects to the average geometry are known, the diffusion tensors then need to be reoriented according to the modification of the reference frame [1]. To this end, we used the Finite Strain method, wherein the rotation components of the transformations were used to reorient the tensor at each voxel.

**Results and Conclusions:** The subjects overlaid on top of each other and the average geometry obtained from our experiments are shown in Figure 1(a) and (b), respectively. The method needed only 5 to 7 iterations until it converged to a stable average geometry. In Figure 1(c), we display the convergence of the groupwise framework measured in terms of the change in intensity values between successive reference geometries. Note that the values dropped by about 82% after the 7$^{th}$ iteration. In Figure 2, we present the results of the Finite Strain reorientation method. Observe that the geometric features of the diffusion tensor fields were preserved. This makes Finite Strain an ideal method for inter-subject DT-MRI registration [1]. Future work will focus on including more datasets in the atlas.

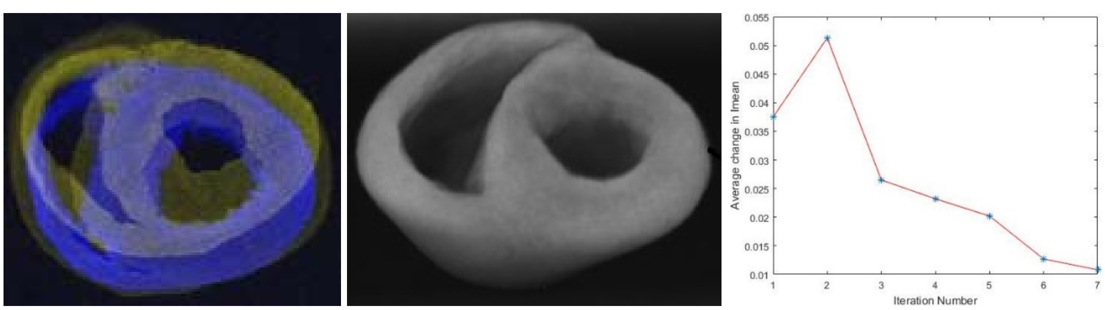


**Figure 1[a,b,c]**. (a) Axial view of the four subjects overlaid on top of each other, (b) the computed average geometry, and (c) the average change in $I_{mean}^{n}$ after each iteration.

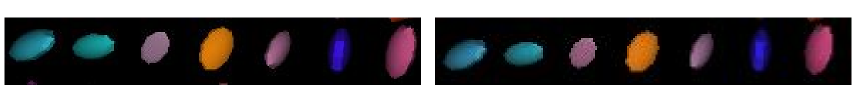

**Figure 2[a,b].** The (a) original and (b) transformed tensors of one of the subjects in the data set.

**References**: [1] Peyrat, J.M., Sermesant, M., et al., IEEE Trans. Med. Imag. 26, 1500-14 (2007), [2] Pop, M., et al., Physics in Medicine and Biology. 58 (15), 5009-28 (2013)