Hyperelastic Modeling of Cardiac Tissue Deformation for Data Registration

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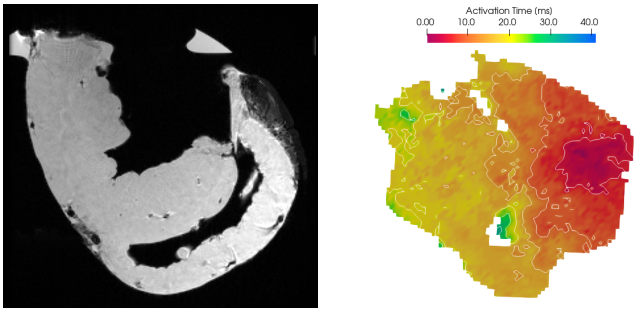
Aim. We are interested in associating functional information from cardiac optical mapping with structural data from high-resolution MRI. Optical maps are 2D images recorded by planar cameras of the activity of a tissue sample stretched on a rectangular frame. After release and fixation, the tissue recovers a different resting shape. High-resolution MR images are then acquired. They display the three-dimensional geometry and microstructure of the same sample. We want to map the optical image on the MR image.



(a) High-resolution MRI (b) Optical map

Figure 1: Experimental images of a right ventricular sheep sample.

Method. The tissue is modeled as a transversely isotropic hyperelastic material (Holzapfel–Ogden type) with a preferred direction aligned with the muscle fibers. From the MRI geometry, we apply forces near the boundary mimicking the wires used to stretch the sample on the rectangular frame. Large deformations are computed using a finite element solver and Newthon's method.

Results and further goals. First results on a simplified geometry show plausible deformations and consistent behavior, supporting the relevance of this approach. They are promising for future applications to real experimental data. Next, we will apply this method to experimental data. Last, an inverse problem will be solved in order to reconstruct the forces that give the best deformation. This will provide a mapping from MR images to the optical reference.