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PATIENT-SENSITIVE ANATOMIC AND FUNCTIONAL 3D MODEL OF THE LEFT VENTRICLE

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ABSTRACT

Early diagnosis and accurate treatment of Left Ventricle (LV) dysfunction significantly increases the patient survival. Impairment of LV contractility due to cardiovascular diseases is reflected in its motion patterns. Recent advances in medical imaging, such as Magnetic Resonance (MR), have encouraged research on 3D simulation and modelling of the LV dynamics. Most of the existing 3D models [1] consider just the gross anatomy of the LV and restore a truncated ellipse which deforms along the cardiac cycle. The contraction mechanics of any muscle strongly depends on the spatial orientation of its muscular fibers since the motion that the muscle undergoes mainly takes place along the fibers. It follows that such simplified models do not allow evaluation of the heart electro-mechanical function and coupling, which has recently risen as the key point for understanding the LV functionality [2]. In order to thoroughly understand the LV mechanics it is necessary to consider the complete anatomy of the LV given by the orientation of the myocardial fibres in 3D space as described by Torrent Guasp [3].

We propose developing a 3D patient-sensitive model of the LV integrating, for the first time, the ventricular band anatomy (fibers orientation), the LV gross anatomy and its functionality. Such model will represent the LV function as a natural consequence of its own ventricular band anatomy. This might be decisive in restoring a proper LV contraction in patients undergoing pace marker treatment.

The LV function is defined as soon as the propagation of the contractile electromechanical pulse has been modelled. In our experiments we have used the wave equation for the propagation of the electric pulse. The electromechanical wave moves on the myocardial surface and should have a conductivity tensor oriented along the muscular fibers. Thus, whatever mathematical model for electric pulse propagation [4] we consider, the complete anatomy of the LV should be extracted.

The LV gross anatomy is obtained by processing multi slice MR images recorded for each patient. Information about the myocardial fibers distribution can only be extracted by Diffusion Tensor Imaging (DTI), which can not provide *in vivo* information for each patient. As a first approach, we have

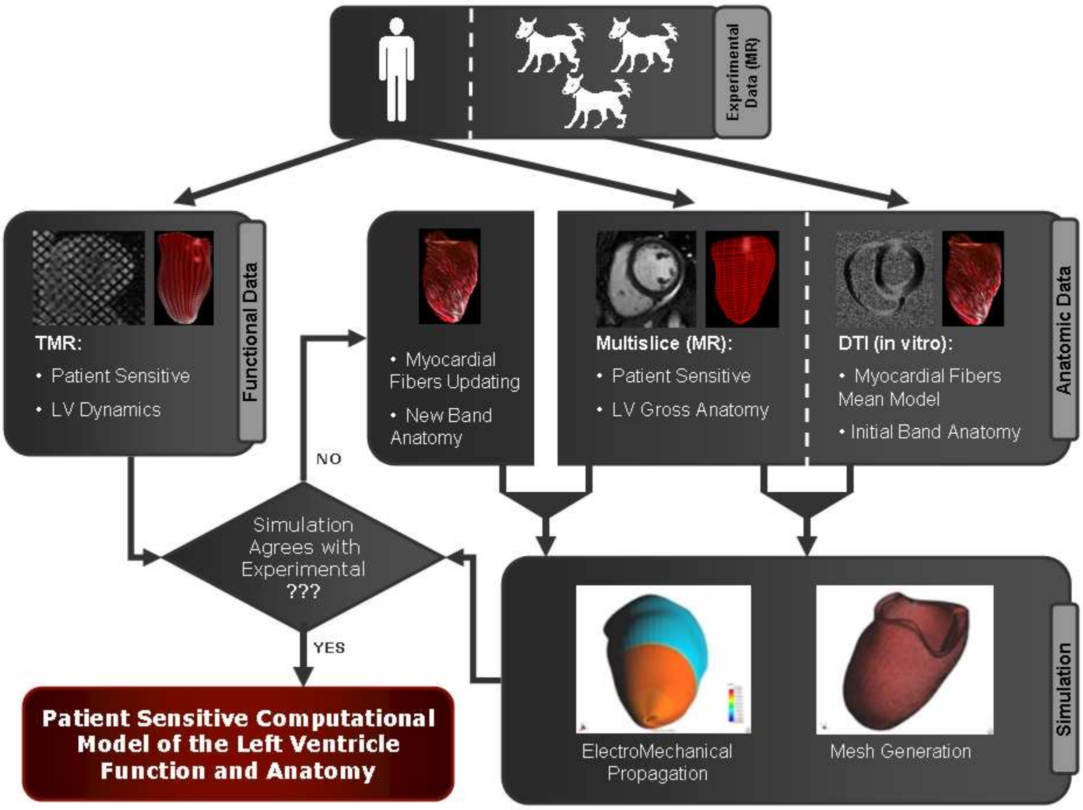

Figure 1: Scheme for the Left Ventricle Patient-Sensitive Model.

computed an average model of fibers from several DTI studies of canine hearts. This rough anatomy is the input for our electro-mechanical propagation model simulating LV dynamics. The average fiber orientation is updated until the simulated LV motion agrees with the experimental evidence provided by the LV motion observed in tagged MR (TMR) sequences. Experimental LV motion is recovered by applying image processing, differential geometry and interpolation techniques to 2D TMR slices [5]. The pipeline in figure 1 outlines the interaction between simulations and experimental data leading to our patient-tailored model.

REFERENCES

[1] J. Li and T. Denney, Left ventricular motion reconstruction with a prolate spheroidal b-spline model, *Phys. Med. Biol.*, vol. **51**, pp. 517-537, 2006.

[2] F. Sachse, *Computational Cardiology: Modelling of Anatomy, Electrophysiology and Mechanics*, LNCS, vol. **2966**, 2004.

[3] F. Torrent-Guasp, M. Kocica, A. Cornoc, et al. Towards new understanding of the heart structure and function, *Eur. J. Cardio-Thorac.*, vol. **27**, pp. 191-201, 2005.

[3] M. Mlcek, J. Neumann, O. Kittnar and V. Novak. Mathematical Model of the Electromechanical Heart Contractile System - Regulatory Subsystem Physiological Considerations, *Physio. Research.*, vol. **50**, pp. 425-432, 2001.

[5] J. Garcia-Barnes, D. Gil, J. Barajas, et al. Characterization of Ventricular Torsion in Healthy Subjects using Gabor filters in a variational framework, *IEEE Proc. CinC*, vol. **33**, pp. 877-880 , 2006.