

Towards Realistic Cardiac MR Image Simulation; Inclusion of the Endocardial Trabeculae in the XCAT Heart Anatomy

Sina Amirrajab¹, William Paul Segars², Cristian Lorenz³, Juergen Weese³, Marcel Breeuwer^{1,4}

¹Biomedical Engineering Department, Eindhoven University of Technology, Eindhoven, The Netherlands. ²Department of Radiology, Duke University Medical Center, Durham, North Carolina, USA. ³Philips Research Laboratories,

2207

Hamburg, Germany. ⁴Philips Healthcare, MR R&D - Clinical Science, Best, The Netherlands

INTRODUCTION

The purpose of this study is to modify the XCAT heart anatomy to increase the realism for simulating cardiac MR images by including realistic trabeculae. To resemble the real anatomy, the trabeculae were precisely modelled based on high spatial resolution cardiac MR image data and integrated into the XCAT anatomical phantom¹.

METHODS

- **Modeling of trabeculae** is based on an open access ex-vivo high-resolution 3D MRI data of a normal human heart suitable for capturing the irregularity of the trabeculae muscular geometry².
- **Creation of voxelized phantom** is preformed using XCAT software with normal anatomical parameters and standard views are obtained from the axial view according to CMR pocket guide.
- **Simulation of CMR images** is based on the improved version of MRXCAT approach³ for b-SSFP with sequence parameters of TR/TE=2.78/1.39, flip angle= 60, 0.5x0.5x4 mm³.

RESULTS

Figure 1 shows the manual segmentations of the LV (red) and RV (blue) chambers with the 3D model corresponding to of the tiny jagged-like muscular structure of the trabeculae anatomy. Figure 2 schematically illustrates how the polygon surface mesh model is 3D-aligned with the heart model embedded into the whole XCAT phantom surfaces. The modified version of the XCAT heart clearly improves the anatomical realism of the simulated images

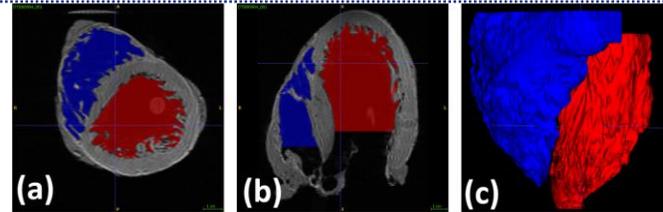


Figure 1 Creation of anatomy-based model for trabeculation of LV and RV myocardium. We performed manual slice-by-slice segmentation of the myocardial trabeculae for the LV (red) and for the RV (blue) in the ITK-SNAP software (a,b) and exported the labels as 3D surface meshes (c).

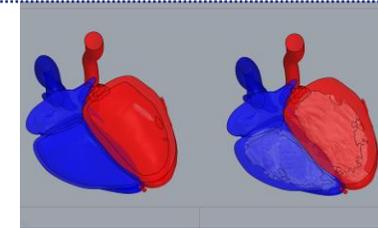


Figure 2 Alignment of the trabeculae model of the LV (red) and the RV (blue) within the inner layer of the original XCAT heart using Rhinoceros surface modelling software. The procedure involves 3D nonlinear transformation and rotation of the trabeculae model to have it incorporated into the LV and RV surfaces.

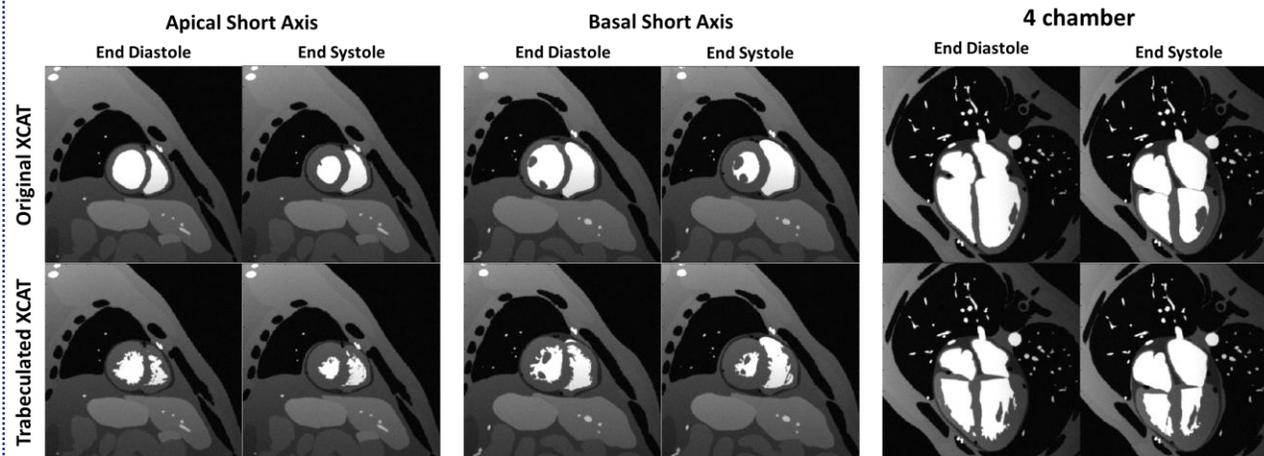


Figure 3 Simulated CMR images. The short axis view at apical and basal slices and 4-chamber view of the original XCAT heart (top row) and the same views for trabeculated XCAT (bottom row) were simulated at end diastolic and end systolic of heart.

CONCLUSION

- Greater realism in cardiac MRI simulation can be achieved by including the trabeculae anatomy into the myocardial wall.
- In pursuit of generating a database of realistic simulated MR images for medical image analysis research, we will focus on further improving the realism of the MR simulation (realistic noise, partial volume, tissue texture)