COMBAT-VT

COMBAT-VT:

NURBS-based isogeometric analysis of a bi-ventricular heart model

Robin Willems[1], Clemens V. Verhoosel[2], Olaf van der Sluis[2,3]

[1]Department of Biomedical Engineering, University of Technology Eindhoven
[2]Department of Mechanical Engineering, University of Technology Eindhoven, [3]Philips Research Eindhoven

Keywords: Isogeometric Analysis | Finite Element Method | Cardiac Mechanics | Patient-specific | Ventricular Tachycardia

MOTIVATION AND OBJECTIVE

Computer simulations provide information that can be used by clinicians to support decision-making (Computational-model-based decision support = COMBAT) regarding the treatment of **Ventricular Tachycardias** (VTs). It is the goal of this **COMBAT-VT** subproject to develop efficient and robust models that can be integrated into the clinical workflow.

SIMULATION WORKFLOW

Our simulation framework combines the **Isogeometric Analysis** (IGA) simulation paradigm [1] with image recognition techniques to obtain **patient-specific** computer models (Fig. 1 & 2). Simulations will be performed directly on a Non-Uniform Rational B-Spline (NURBS) bi-ventricular geometry. Computational costs are improved because of the limited number of control points that quantify the geometry.

NURBS template

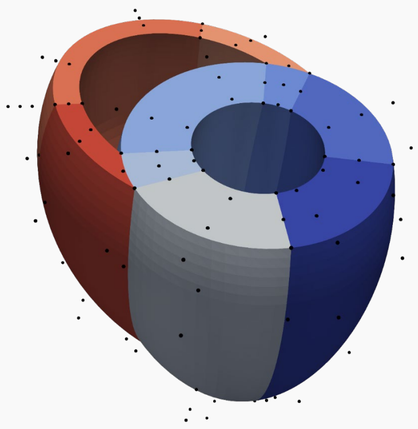


Fig. 1 Idealized NURBS bi-ventricle geometry, parametrized by a minimum number of control points.

Echo data

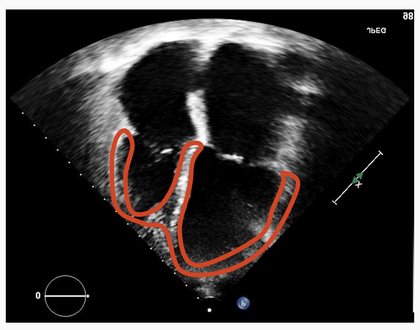
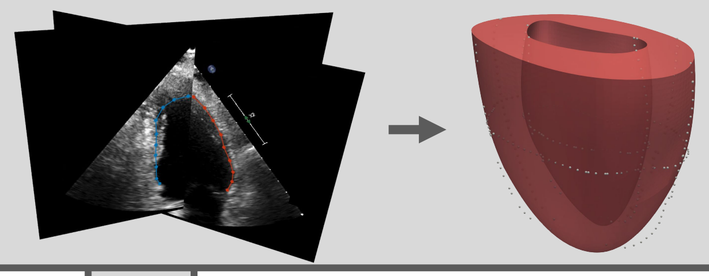


Fig. 2 Echocardiogram data is used to extract patient-specific geometry features.

Patient-specific geometry



Cardiac Model

Mechanics

Activation

Circulation

Existing cardiac models [2] are solved monolithic using the IGA paradigm in a robust and efficient manner with clinical data.

Additional clinical data

Results

Left ventricle verification

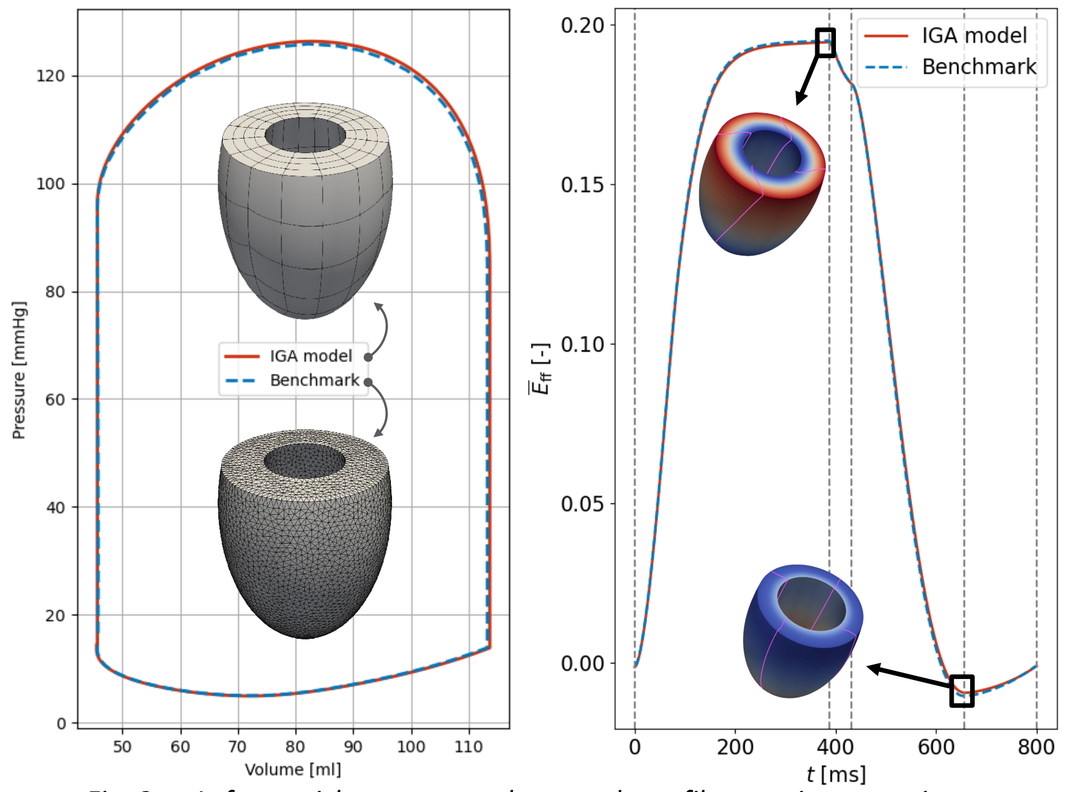
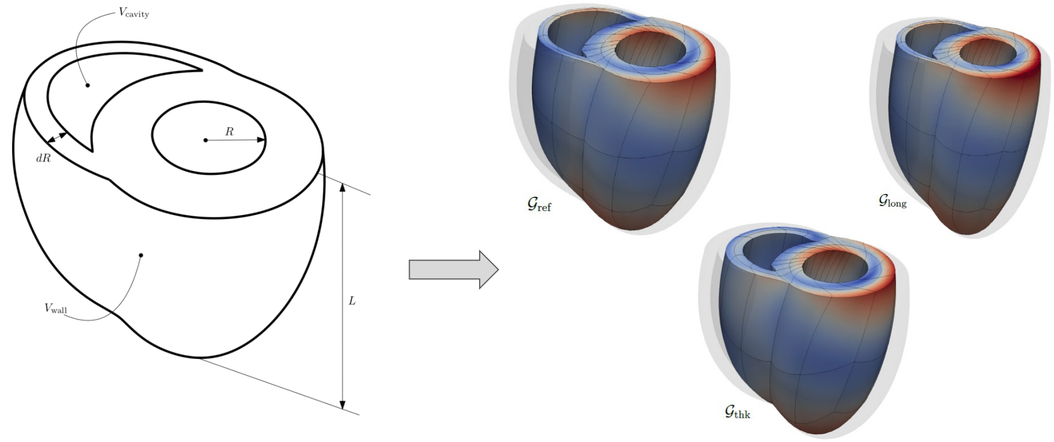


Fig. 3 Left ventricle pressure-volume and myofiber-strain comparison between the developed IGA model and external benchmark results (FEnics) [2].

Fast geometry variations



PROJECT OUTLOOK

IGA has the potential to yield robust geometry and analysis models in the considered scenario of limited input data. Future project steps focus on the automation of image-based geometry reconstruction, while extending the model functionality, validation (Fig. 3), and **clinical integration**. Attention will be given to parameter sensitivity and uncertainty quantification, which is essential for **VT prediction**.

VT Prediction

REFERENCES

[1] Hughes, T. J. R. et al. (2005). *Isogeometric analysis: CAD, finite elements, NURBS, exact geometry and mesh refinement,* Comput. Methods in Appl. Mech. Eng., 194.39, 4135 - 4195.

[2] Bovendeerd, P. H. M. et al. (2009). *Determinants of left ventricular shear strain. Am J Physiol Heart Circ Physiol.* 297(3):H1058-68.

Contact details: r.willems@tue.nl