

Isogeometric Analysis of an Electromechanical Bi-Ventricular Heart Model

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Isogeometric Analysis of an Electromechanical Bi-Ventricular Heart Model

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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** (*combatvt.nl*) 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.

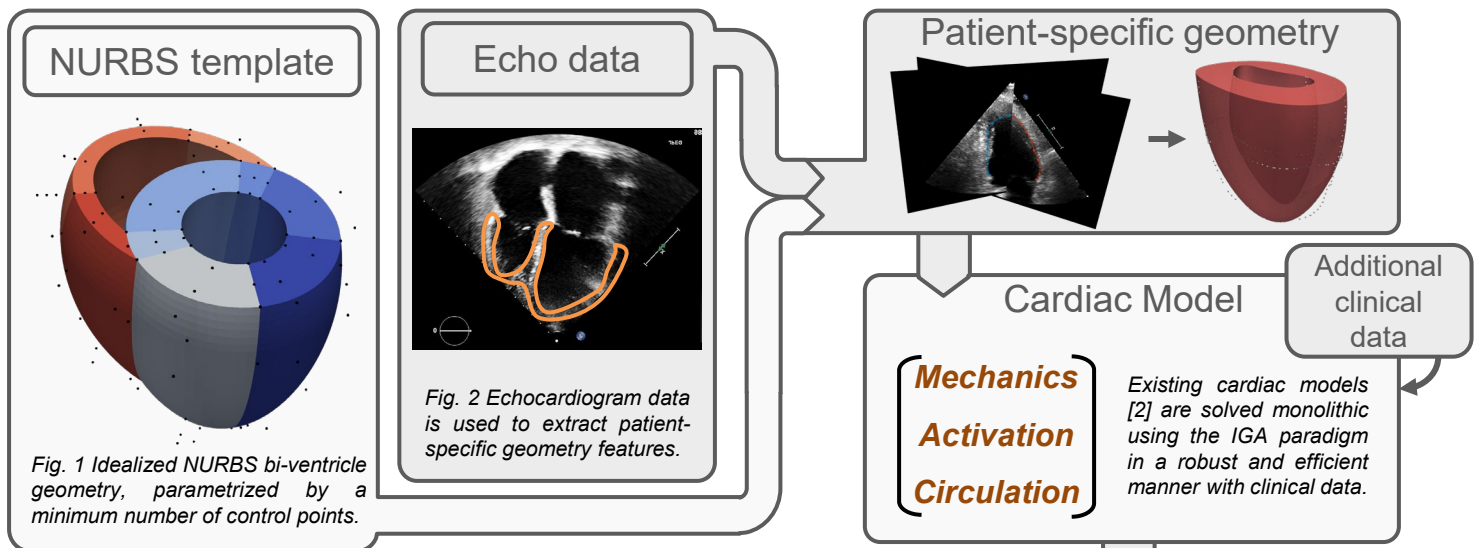


Fig. 1 Idealized NURBS bi-ventricle geometry, parametrized by a minimum number of control points.

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

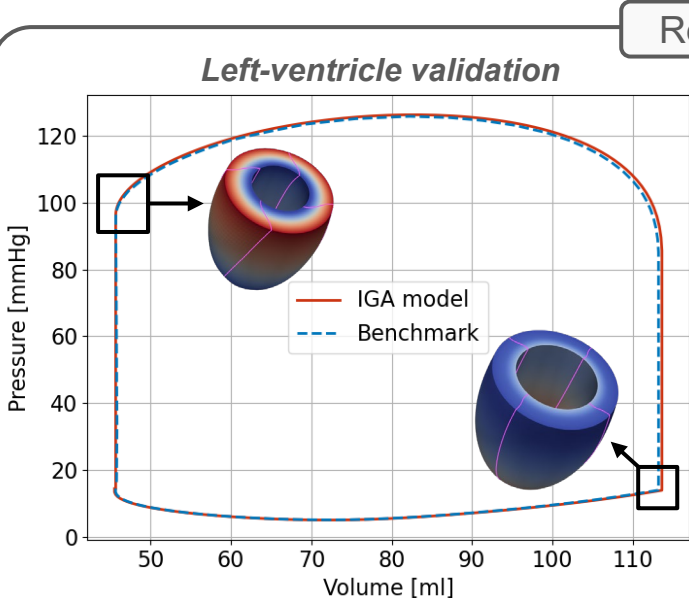
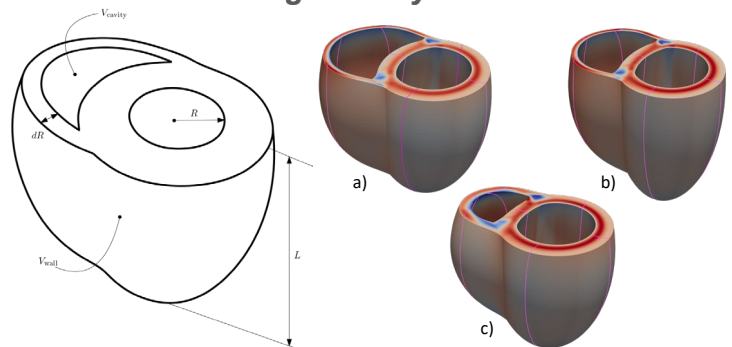


Fig. 3 Left-ventricle pressure-volume comparison between the developed IGA model (5000 degrees of freedom) and external (FEA) benchmark results (469 734 degrees of freedom) [2].

Results

Fast geometry variations



Project outlook

IGA has the potential to yield robust geometry and analysis models in the considered scenario of sparse 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.