

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

**Citation for published version (APA):**

Willems, R., van der Sluis, O., & Verhoosel, C. V. (2022). *NURBS-based isogeometric analysis of a bi-ventricular heart model*. Abstract from 10th International Conference on Isogeometric Analysis, IGA 2022, Banff, Alberta, Canada.

**Document status and date:**

Published: 01/11/2022

**Document Version:**

Author's version before peer-review

**Please check the document version of this publication:**

- A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
- The final author version and the galley proof are versions of the publication after peer review.
- The final published version features the final layout of the paper including the volume, issue and page numbers.

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

Patients suffering from Ventricular Tachycardias (VTs, a fast abnormal heart rate), require ablation therapy to treat the scar tissue located on the left ventricle which causes VTs. Success rates are considered moderate (50-80%) and can be elevated using patient-specific three-dimensional computer models of the human heart, specifically the (bi-)ventricles.

Current electromechanical ventricular models using Finite Element Analysis (FEA) are computationally expensive, which is impractical for clinical applications. Furthermore, patient-specific FEA models rely on accurate input data to produce meaningful results. We propose an approach in which the Isogeometric Analysis (IGA) paradigm [1] is applied to existing mechanical ventricular models [2] subject to limited available input data. IGA enables the construction of smooth discretized geometries, which require fewer degrees of freedom, making them ideal for clinical applications.

In this project, we present a method for constructing a template bi-ventricle NURBS geometry comprised of two truncated ellipsoids, using multipatches. We target the mapping of the template geometry onto patient-specific ultrasound scan-data. The cardiac mechanics and zero-dimensional circulatory system are solved within the IGA framework through a monolithic strategy. The results are compared to an existing model which employs the traditional finite element approach. The novelty of our research resides in the implementation of IGA for a patient-specific cardiac model that is based on scan-data. IGA is expected to reduce the computational effort [3] when compared to the currently used methods in the literature while enabling an accurate representation of the cardiac mechanics.

[1] Hughes, T.J., Cottrell, J.A. and Bazilevs, Y., 2005. Isogeometric analysis: CAD, finite elements, NURBS, exact geometry and mesh refinement. *Computer Methods in Applied Mechanics and Engineering*, 194, 4135–4195.

[2] Pluijmert, M., Delhaas, T., de la Parra, A.F., Kroon, W., Prinzen, F.W. and Bovendeerd, P.H., 2017. Determinants of biventricular cardiac function: a mathematical model study on geometry and myofiber orientation. *Biomechanics and modeling in mechanobiology*, 16, 721-729.

[3] Pegolotti, L., Dede, L. and Quarteroni, A., 2019. Isogeometric analysis of the electrophysiology in the human heart: Numerical simulation of the bidomain equations on the atria. *Computer Methods in Applied Mechanics and Engineering*, 343, 52–72.