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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.

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[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.