Karlsruhe Institute of Technology

Institute of Biomedical Engineering

Universal atrial coordinates aligned with the clinical consensus on standardized bi-atrial regionalization

Bachelor's Thesis

Motivation

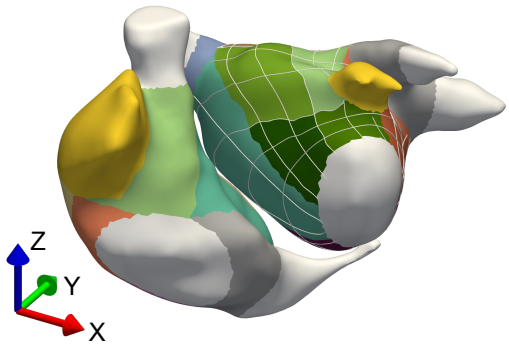
More than 50 million individuals worldwide are affected by atrial fibrillation (AF), which is the most common sustained arrhythmia and leads to an increased risk of stroke and heart failure. Current treatment strategies largely follow a one-size-fits-all approach and achieve only limited success rates, underscoring the need for personalized treatment options. To enable localized analyses of diseased tissue, as well as to support the planning and comparison of treatment strategies across patients, imaging modalities and clinical centers, a common reference system is required.

The clinical consensus statement on a standardized bi-atrial regionalization by the European Heart Rhythm Association (EHRA) and the European Association of Cardiovascular Imaging (EACVI) marks an important step into this direction [1]. Building on this, we developed an algorithm that automatically applies this standardized regionalization to any bi-atrial geometry, thereby reducing inter-operator variability and enabling consistent, regional quantitative comparisons [2].

While these advances rely on a discrete regionalization of the atria, a continuous parametrization – such as the universal atrial coordinates framework presented in [3] – aligned with the EHRA/EACVI consensus statement would offer additional advantages. It ensures consistent alignment of coordinates with anatomical regions across geometries, provides a clear coordinate-based language for spatial description, and enables the mapping of data between geometries. With a new standard for atrial regionalization now established, but no aligned continuous parametrization available, this thesis offers you the opportunity to contribute a coordinate system with the potential for broad use in future research.

Student Project

In this thesis, you will develop a coordinate system for both atria, explicitly aligned with the published standardized atrial regionalization. You will begin by defining the requirements and key characteristics of coordinate systems, followed by an analysis of the strengths and limitations of the existing universal atrial coordinates implementation. Next, you will perform a literature research on methods for deriving coordinates on 3D surfaces. Finally, you will implement the selected method(s) in Python and validate the resulting coordinate system using bi-atrial geometries obtained from computed tomography (CT), magnetic resonance imaging (MRI) and electroanatomical mapping (EAM).



Standardized bi-atrial regionalization, with exemplary coordinates in the left atrium.

[1] Althoff, T.F., Anderson, R.H., Goetz, C. et al. 2025. Europace 27. doi.org/10.1093/europace/euaf134
[2] Goetz, C. et al. 2024. Computing in Cardiology Conference 2024. doi.org/10.22489/CinC.2024.316
[3] Roney, C. et al. 2019. Medical Image Analysis 55. doi.org/10.1016/j.media.2019.04.004

Notes

Experience in Python is desirable.
Basic knowledge in atrial anatomy is a plus.
The thesis can be conducted in English or German.
The start date is flexible, preferably in April 2026.

Research Area

Computational Cardiac Modeling, Cardiac Anatomy

Course of Studies

Computer Science, Computational Engineering, BME, ETIT, Math

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