Statistical shape model of healthy, human, biventricular anatomy

Commonly used acronym: *SSM*

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Organisation

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SCOPE OF THE METHOD

The Method relates to	Human health
The Method is situated in	Basic Research
Type of method	In silico

DESCRIPTION

Method keywords

Principal Component Analysis

Digital Twin

Statistical Shape Models

Computational Cardiology

Ventricles

Computational Mesh

Anatomical Model

Scientific area keywords

Cardiology

Cardiovascular Imaging

Cardiac Anatomy

Simulation

Method description

We developed a biventricular statistical shape model (SSM) from high-resolution cardiac CT scans from 271 healthy individuals. Leveraging the diversity captured by our biventricular SSM, we created a synthetic cohort of anatomically detailed, high-resolution, biventricular meshes. The geometries in this cohort were each annotated with anatomical labels and fiber orientations. We made both the SSM and the synthetic cohort publicly available. This cohort, and possibly even more synthetic geometries derived from our SSM, can be used for large-scale (electrophysiological) simulation studies. Additionally, they serve as an important building block toward population-level cardiac digital twins (CDTs). Such CDTs, also called virtual cohorts, have application potential in virtual clinical trials. We envision the use of our anatomical cohort of ready-to-use biventricular meshes, representative of a healthy population, to create a healthy virtual control population for such trials.

Method status

Published in peer reviewed journal

PROS, CONS & FUTURE POTENTIAL

Advantages

- High resolution,
- Volumetric biventricular SSM and meshes,
- Derived from cardiac CT scans of healthy subjects (male: normal + athletes, female: normal),
- Suitable for electrophysiological simulations.

Challenges

- Cohort with both normal, healthy subjects, as well as endurance athletes.
- Male subjects are taken from a prospective cohort trial (normal healthy subjects + endurance athletes), whereas female subjects are taken from a clinical referral to a cardiac CT scan.
- The non-conductive cardiac skeleton is not included in the SSM and synthetic meshes.

Modifications

More CT scans of healthy subjects can be included, to obtain an even more complete and detailed SSM.

Future & Other applications

We envision applications in the field of (electrophysiological) simulation. We also envision the use of the synthetic cohort of biventricular anatomies in virtual clinical trials.

REFERENCES, ASSOCIATED DOCUMENTS AND OTHER INFORMATION

References

Van Santvliet, L., Zappon, E., Gsell, M. A. F., Thaler, F., Blondeel, M., Dymarkowski, S., Claessen, G., Willems, R., Urschler, M., Vandenberk, B., Plank, G., & De Vos, M. (2025). Integrating anatomy and electrophysiology in the healthy human heart: Insights from biventricular statistical shape analysis using universal coordinates. Computers in Biology and Medicine, 192, 110230. https://doi.org/10.1016/j.compbiomed.2025.110230

Links

Zenodo dataset: Synthetic biventricular cohort and statistical shape model

Github code repository: Biventricular statistical shape model

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