Quantification of intracardiac flow

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Background

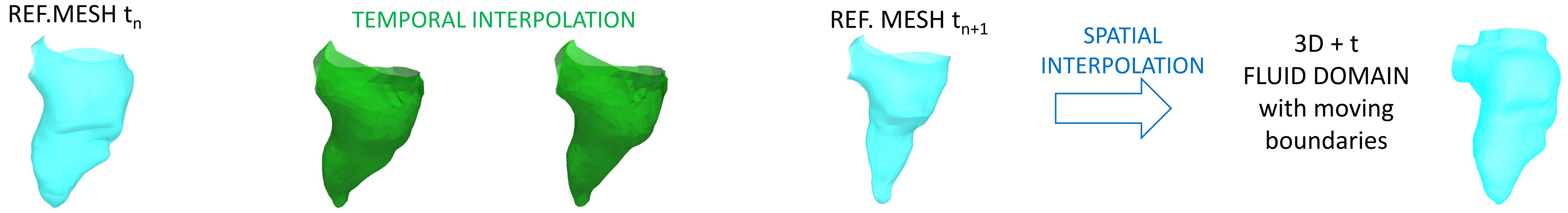
Vortex formation is an important mechanism in physiological Left Ventricle (LV) fluid dynamics contributing to efficient emptying of the LV and prevention of stasis [1]. Vortex formation is difficult to measure directly in vivo.

Aim: Develop a computational fluid dynamics (CFD) model with prescribed moving boundaries of the LV wall derived from MRI imaging that can provide tools for quantitative assessment of intra cardiac flow.

Methods

In order to replicate and impose the LV wall displacement (as derived from clinical images) a Mapping Tool is **needed** to obtain **conformal meshes** that share the **same topology and number of nodes**. In this way, the displacement of each node can be assigned univocally in the CFD model.

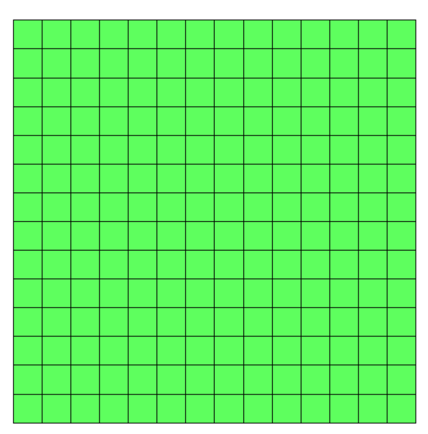
CONCEPTUAL FRAMEWORK OF CFD MODEL



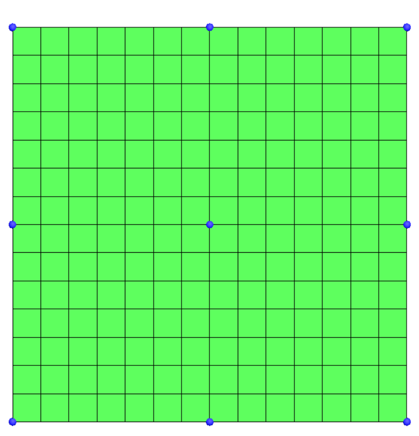
Bavo et al. [2] developed a mapping method that has been applied to 3D ultrasound data, but the method is cumbersome and often results in distorted meshes. A new method, based on isoparametric transformations, has been developed as part of my project. The method was applied to the LV data as used by Bavo et al.

Mapping tool -> Steps

1. Define the patch

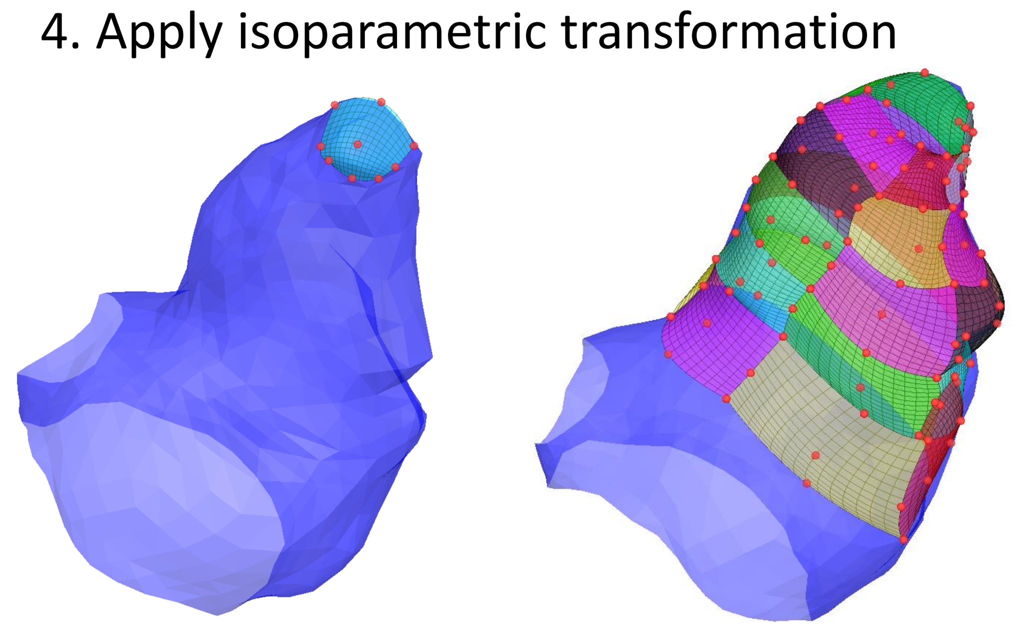


2. Define the initial control points (CPs)

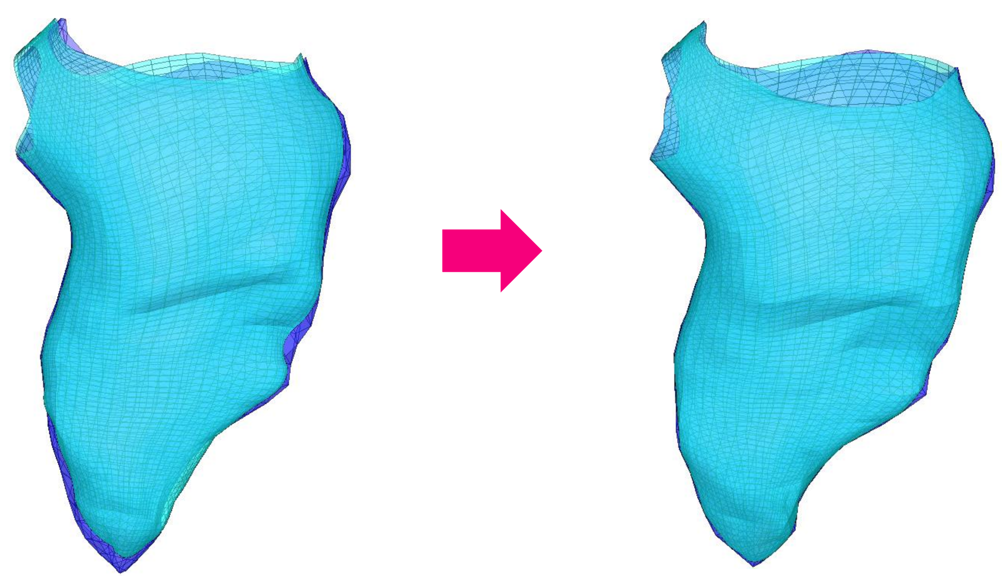


3. Place the final CPs in the LV surface at t0

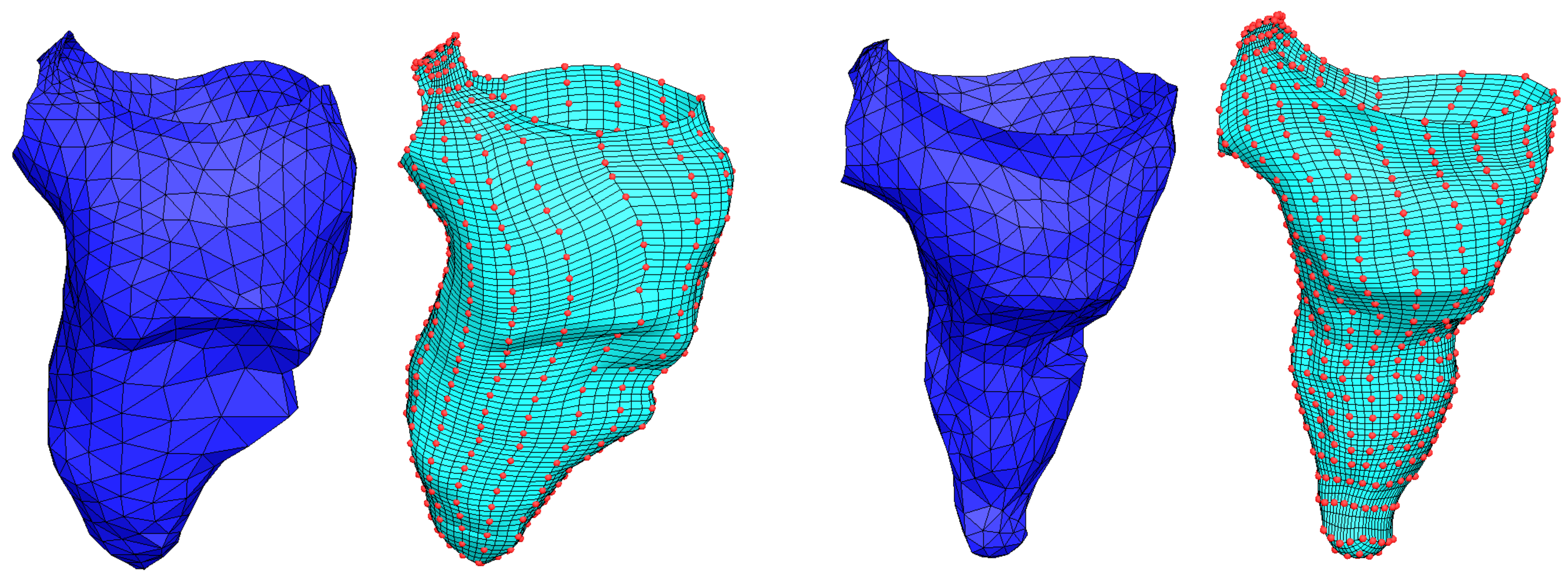
4. Apply isoparametric transformation



5. Manually pull the CPs of the previous LV configuration to fit the shape of the successive LV configurations for the entire cardiac cycle

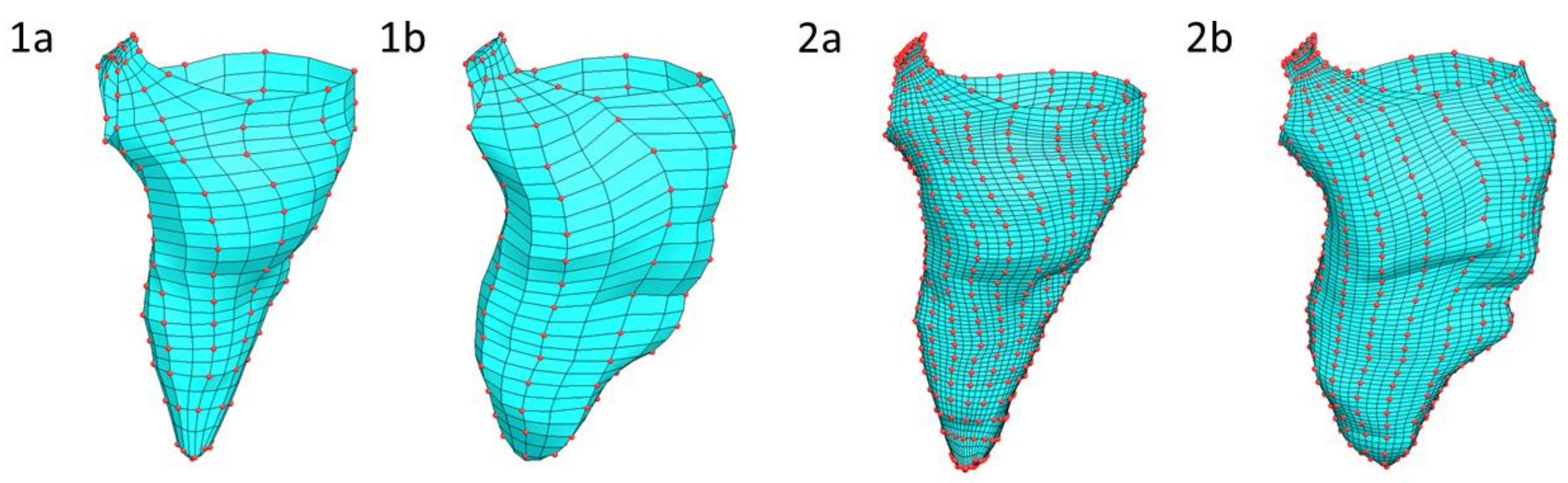


QUALITATIVE COMPARISON BETWEEN ORIGINAL MESHES AND MAPPED ONES

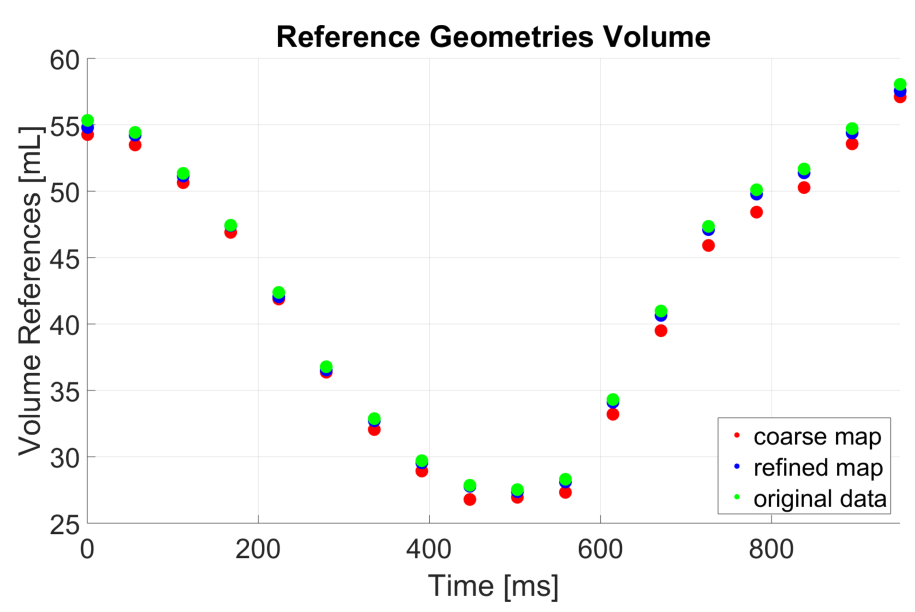


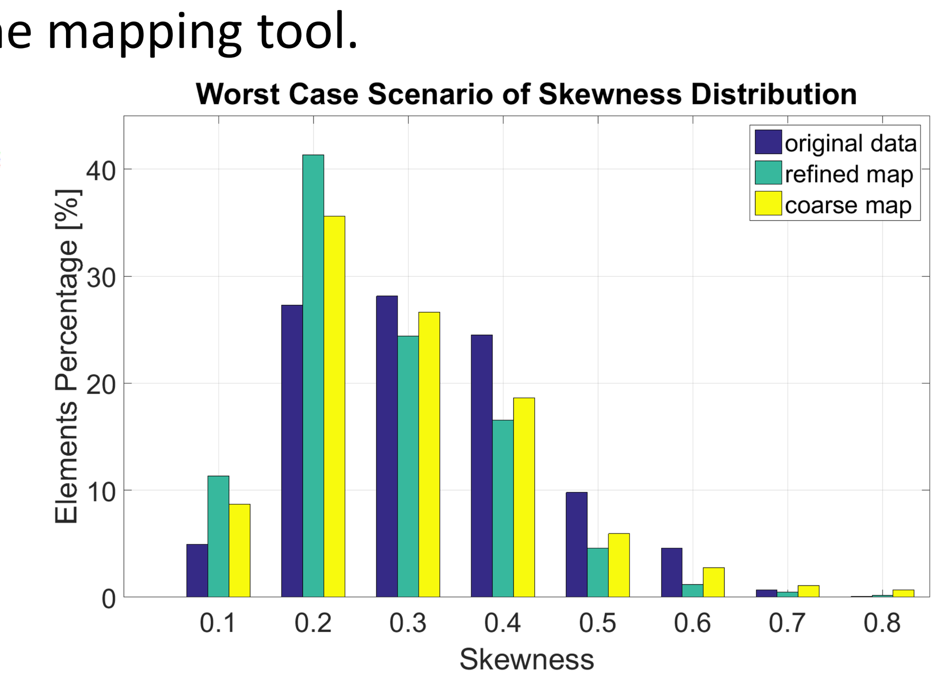
Results

Two different mappings were performed (97 and 484 CPs) to evaluate the **spatial accuracy** and **mesh quality** of the mapping tool.



Coarse (1) and refined (2) mapping at peak systole (a) and peak diastole (b)





Conclusions and Future Planning

The developed Mapping Tool allows to create high quality meshes giving the chance to instantly change the type (quad, tri) and number of elements.

Further steps will be focused on the automatization of the tool.

PERIOD	TASKS
Dec-16	Automatization of Mapping Tool, Parametric model of the Mitral Valve kinematics
Mar-17	Mapping tool application on clinical images (1st paper)
May-Jul 17	IBM model (Milan)
Dec-17	2nd paper on IBM model

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[1] Seo et al., Phys. Fluids , 2014, 26 (12190-1). [2] Bavo et al., Biomed Eng Online, 2016, 15(1):107.

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