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Fluid-structure interaction calibration from 4d-flow MRI

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For pathologies related to abnormal aortic flow (as for instance thoracic aneurisms related to bicuspid valve condition), it is of the utmost relevance to develop precise methods of early diagnosis. Among the sources of data on the circulation, medical imaging is the most used non-invasive one in the clinical practice. The 4dFlow MRI measures the 3d velocity field of a tissue. Such a rich modality, which is more and more available, could make it possible to consider the calibration of a full fluid-structure interaction model, as proposed in [1].

In the present work, we will consider, first, a filtering method to estimate the position and the velocity of a blood vessel wall by using 4d-flow MRI images. The method is based on a coupling between a Kalman Filter and a minimising movement. Starting from an initial geometrical configuration (available from an atlas or coming from a segmentation of a single anatomical image of the patient), we track the dynamics of the wall by using the data from the 4d-flow. The use of a Kalman filter makes it possible to have, quite naturally, a notion of covariance of the state, providing an information on the uncertainty we have when reconstructing the wall kinematics. Second, we will present a full fluid-structure interaction (FSI) calibration, based on the coupling between a sequential state estimation and a unique continuation method (detailed in [2]). The use of the unique continuation and the fact that we measure the velocity field everywhere will make it possible to estimate the boundary conditions in a non-parametric way.

Several test cases will be presented to assess the properties of the methods.

REFERENCES

[1] *Bertoglio, C., Chapelle, D., Fernandez, M., Gerbeau J.-F. and Moireau, P. "State observers of a vascular fluid-structure interaction model through measurements in the solid", Computer Methods in Applied Mechanics and Engineering, Vol. 256, 149-168) (2013).*

[2] *Boulakia, M., Burman, E., Fernandez and Voisembert, E. "Data assimilation finite element method for the linearized Navier-Stokes equations in the low Reynolds regime", Inverse Problems, Vol. 36 (8), (2020).*