

Patient-Specific Velocity Boundary Conditions from Phase Contrast Magnetic Resonance Imaging

Andrea Torti

Università degli Studi di Pavia

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Supervisor: Simone Morganti, PhD

Outline

- Computational Fluid Analysis in the Biomedical Field
- Goal of the thesis
- From PC MRI data to patient-specific velocity profiles
- Conclusions and Future Works

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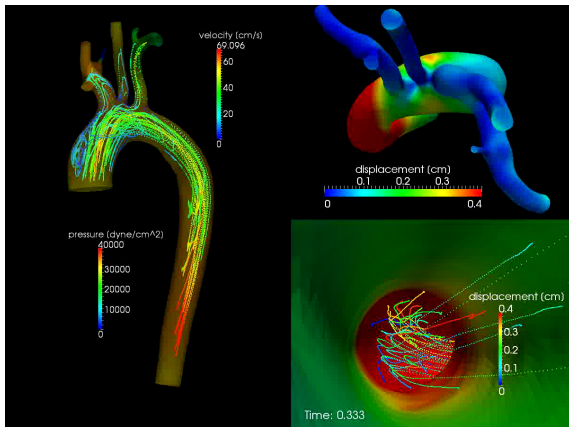
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Computational Fluid Analysis



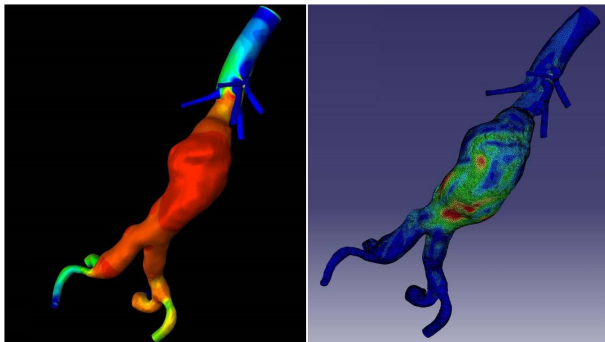
Computational Fluid Analysis (FSI/CFD) is:

- non-invasive
- potentially very accurate
- predictive

Therefore very useful in the Biomedical field

Computational Fluid Analysis (FSI/CFD)

A widely investigated issue for practical purposes:



- Gerbeau and Vidrascu, 2003 —> Algorithms for FSI
- Papaharilaou et al., 2006 —> FSI for Abdominal Aortic Walls Stress
- Bluestein et al., 2008 —> FSI for Abdominal Aortic Aneurysm

FSI/CFD Recipe

...What is needed?



Geometrical Domain

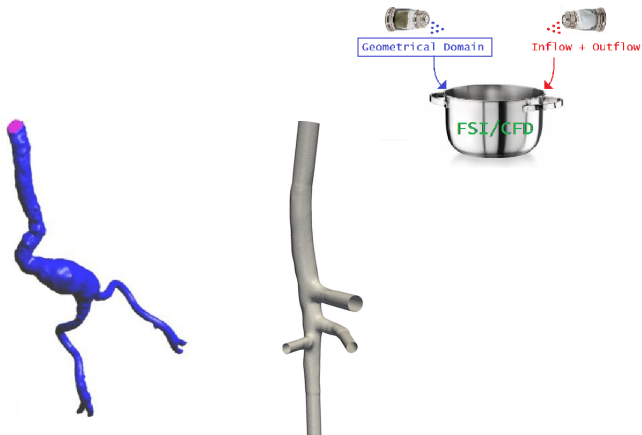


Inflow + Outflow



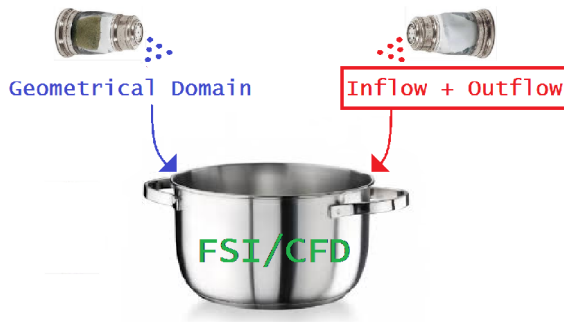
FSI/CFD

Geometrical Domain - Patient-Specific Approach



- Nealand and Kerckhoffs, 2009 —> Progress in Patient-Specific Approaches
- Auricchio et al., 2014 —> CFD for TEVAR evaluation

Aim of the thesis

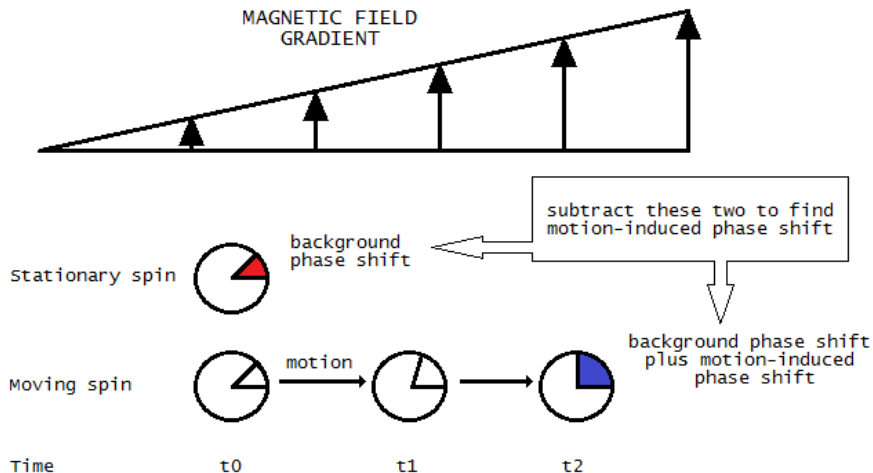


GOAL

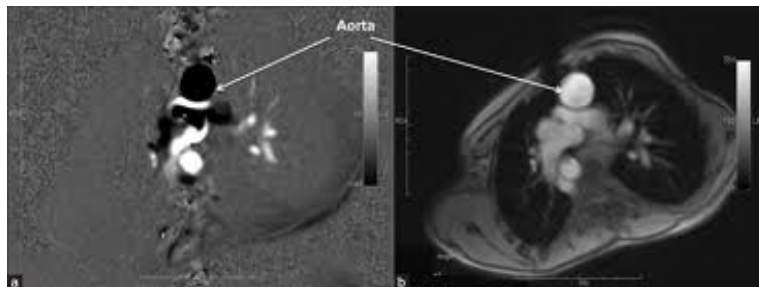
Definition of a **time and space-dependent** Aortic Inflow using Patient-Specific Data from Phase Contrast Magnetic Resonance Imaging

Available Data - PC MRI

PC-MRI: physical principles



Two kinds of data



Unlike standard MRI, PC-MRI also employs information from [phase maps](#)

Clinical Data

30 phase maps (ascending aorta slice) extracted via PC MRI at I.R.C.C.S. San Donato, Milan

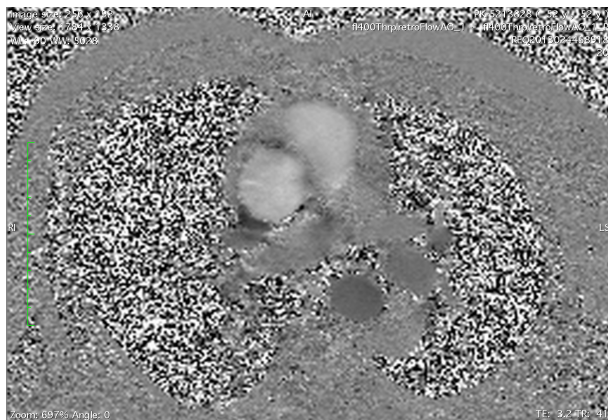
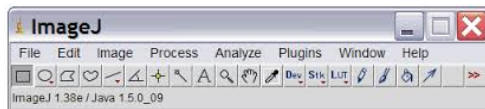
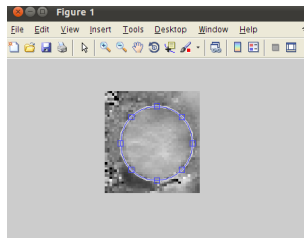


Image Cropping and Segmentation

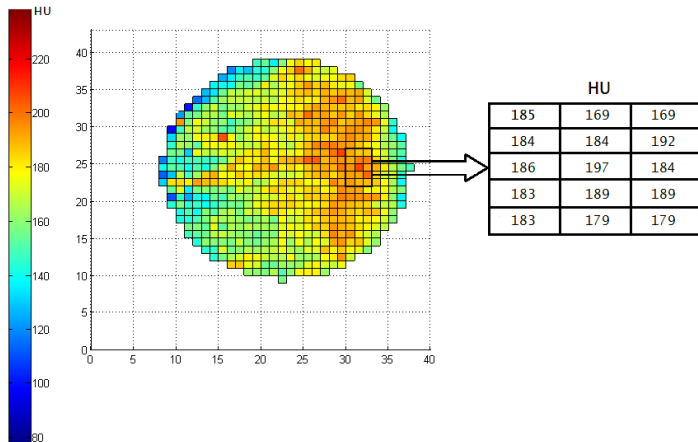
1) Rectangular, Automatic Cropping with ImageJ



2) Elliptical, Semi-Automatic Segmentation with Matlab



From Images to Matrices

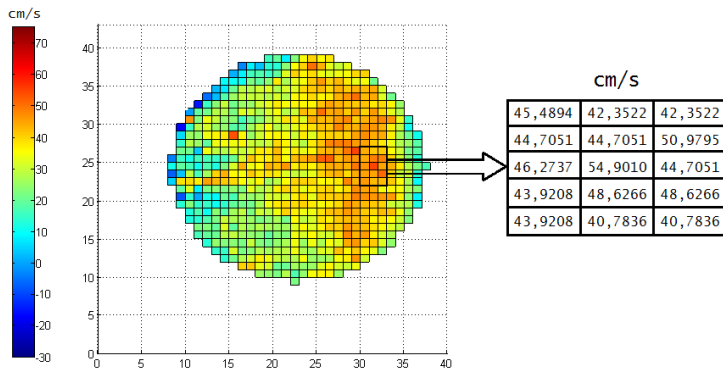


Once in Matlab, each image is related to a matrix, whose cells contain values in Hounsfield units (HU, from 0 to 255, measuring tissue density).

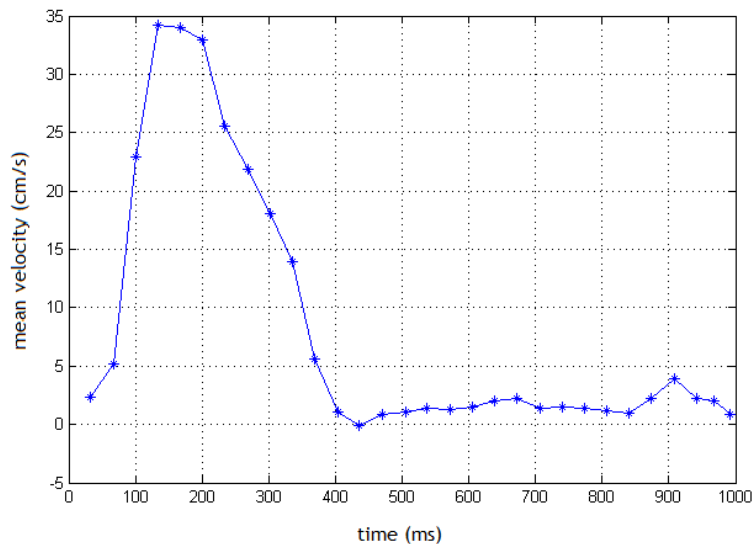
From Hounsfield Units to Velocities

- In PC-MRI, mid-gray represents steady tissues ($HU_0 = 127$)
- $HU_{max} = 255 \rightarrow$ MRI V_{enc} (in this case, 200 cm/s)
- Being $R = V_{enc}/HU_{max}$, we can use the following relation:

$$v(i,j) = (HU(i,j) - HU_0)R$$

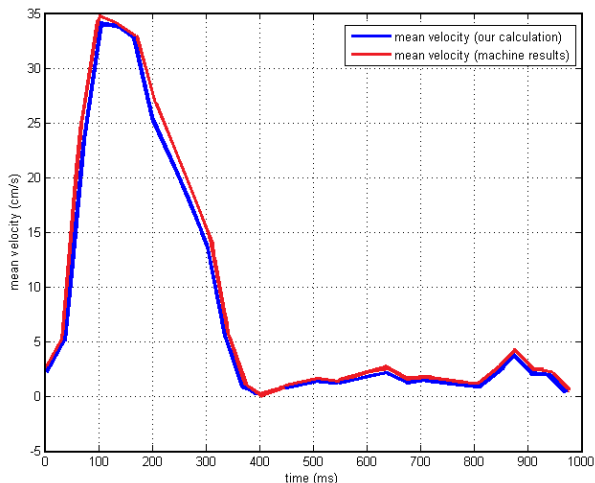


Mean Velocities Calculations



Comparing Datasets

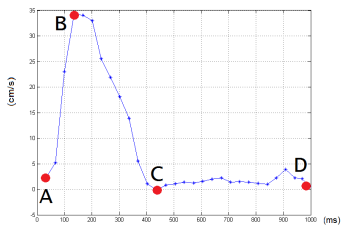
Our Data vs Machine-provided Data



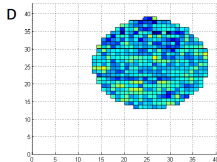
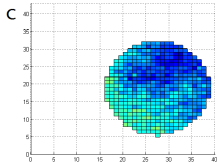
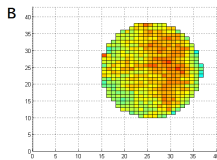
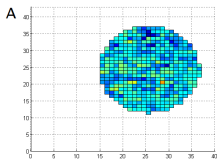
In blue, our plot representing mean velocity vs time, compared to the data provided by I.R.C.C.S. San Donato (in red)

Results

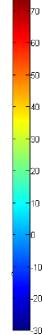
mean velocity vs time



space-dependant velocity profiles



cm/s



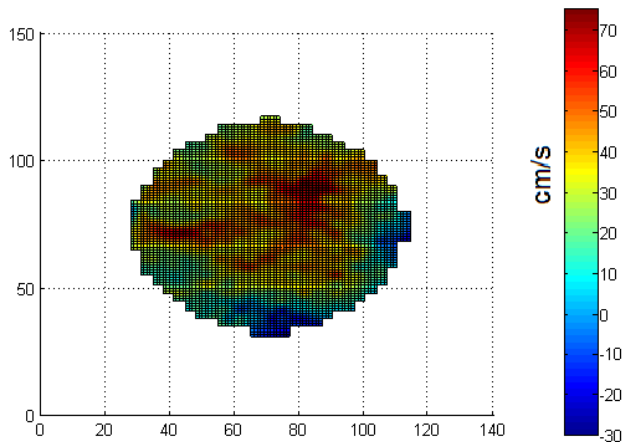
Conclusions

In the present work:

- literature review on computational fluid analysis
- collection of patient-specific PC MRI data
- elaboration of the provided data to obtain time- and space-dependant velocity profiles

Obtained patient-specific aortic inflow from PC MRI is in good agreement with machine-provided data

Future Work: Data interpolation



- Data are represented on a finer grid (but still discrete!)
- We would need an interpolant function \rightarrow (LIFE V)

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