



Grupo de Inteligencia Computacional



Thrombus Change Detection after Endovascular Abdominal Aortic Aneurysm Repair

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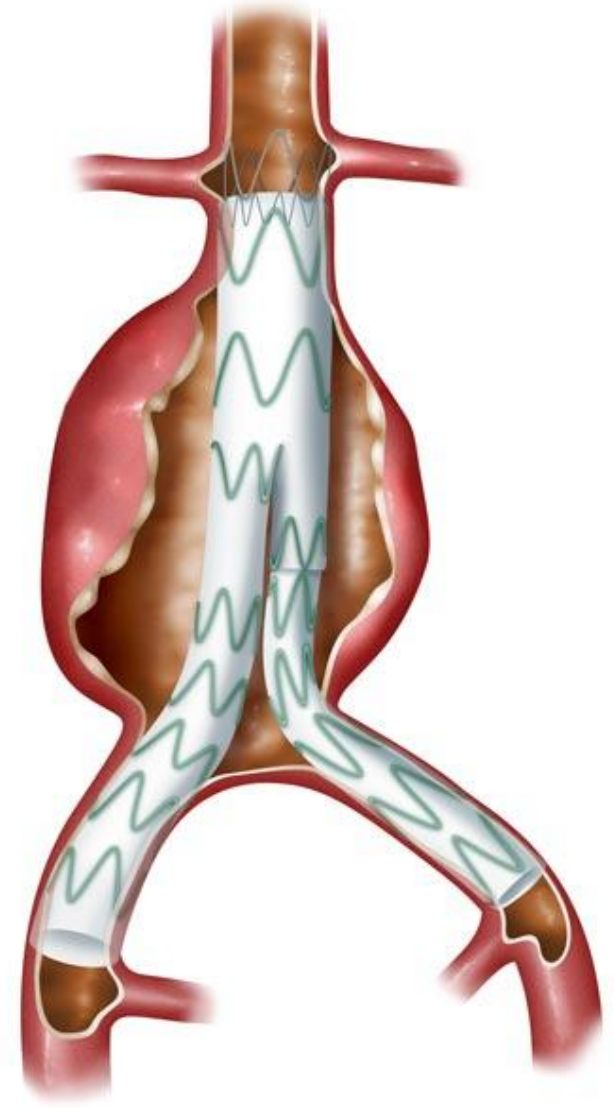
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Outline

- Introduction
- Methods
 - Image Segmentation
 - Image Registration
- Results
- Conclusions

Introduction

- Abdominal Aortic Aneurysm(AAA) is a focal dilation in the abdominal aorta
- EVAR: endovascular prosthesis insertion
- Prosthesis displacement/endoleaks
→Expansion and risk of rupture
- Postoperative monitoring required



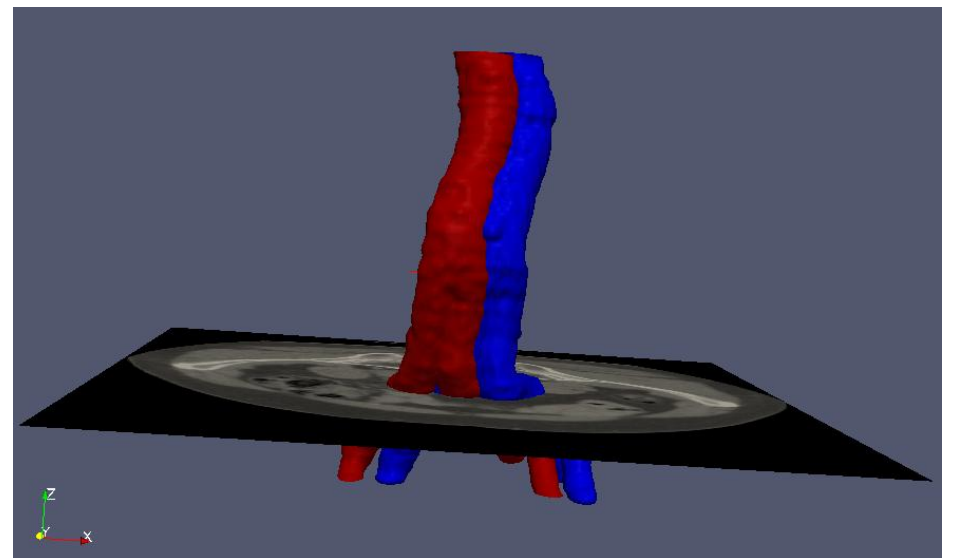
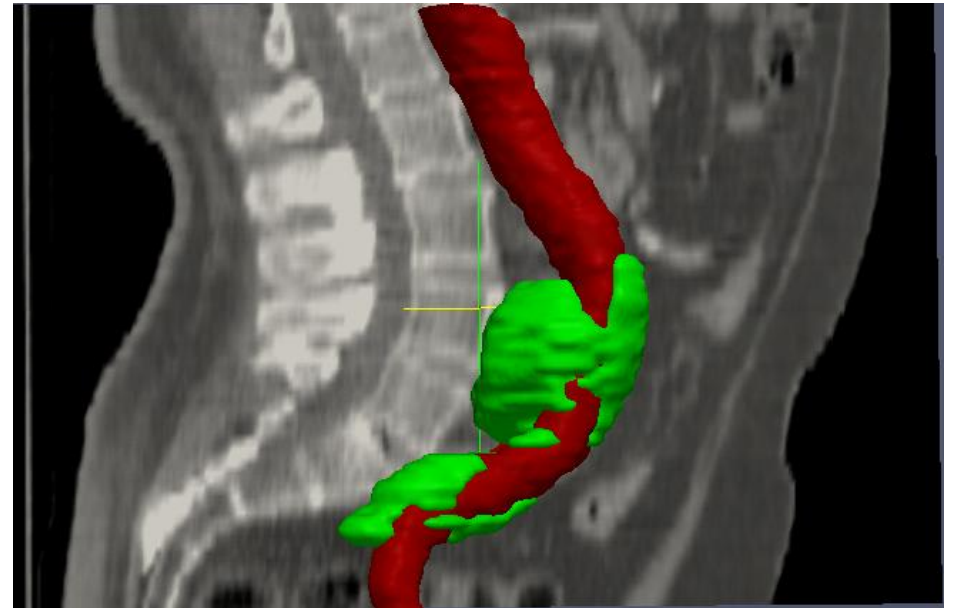
Introduction

- Monitoring by Computerized Tomography (CT) images
- Available in clinical routine as sets of 2D images
- Image processing techniques for visual and quantitative analysis
- Several approaches: texture analysis in the thrombus.



Introduction: our approach

- Estimation of the volumetric variations of the thrombus as well as its deformation.
- Segmentation of the lumen and thrombus.
- Register the lumen of the aorta of the datasets to be compared → Fixed reference system for the thrombus.
- Integration in a medical image processing platform.



Region Growing based
Lumen Segmentation

Thrombus Segmentation

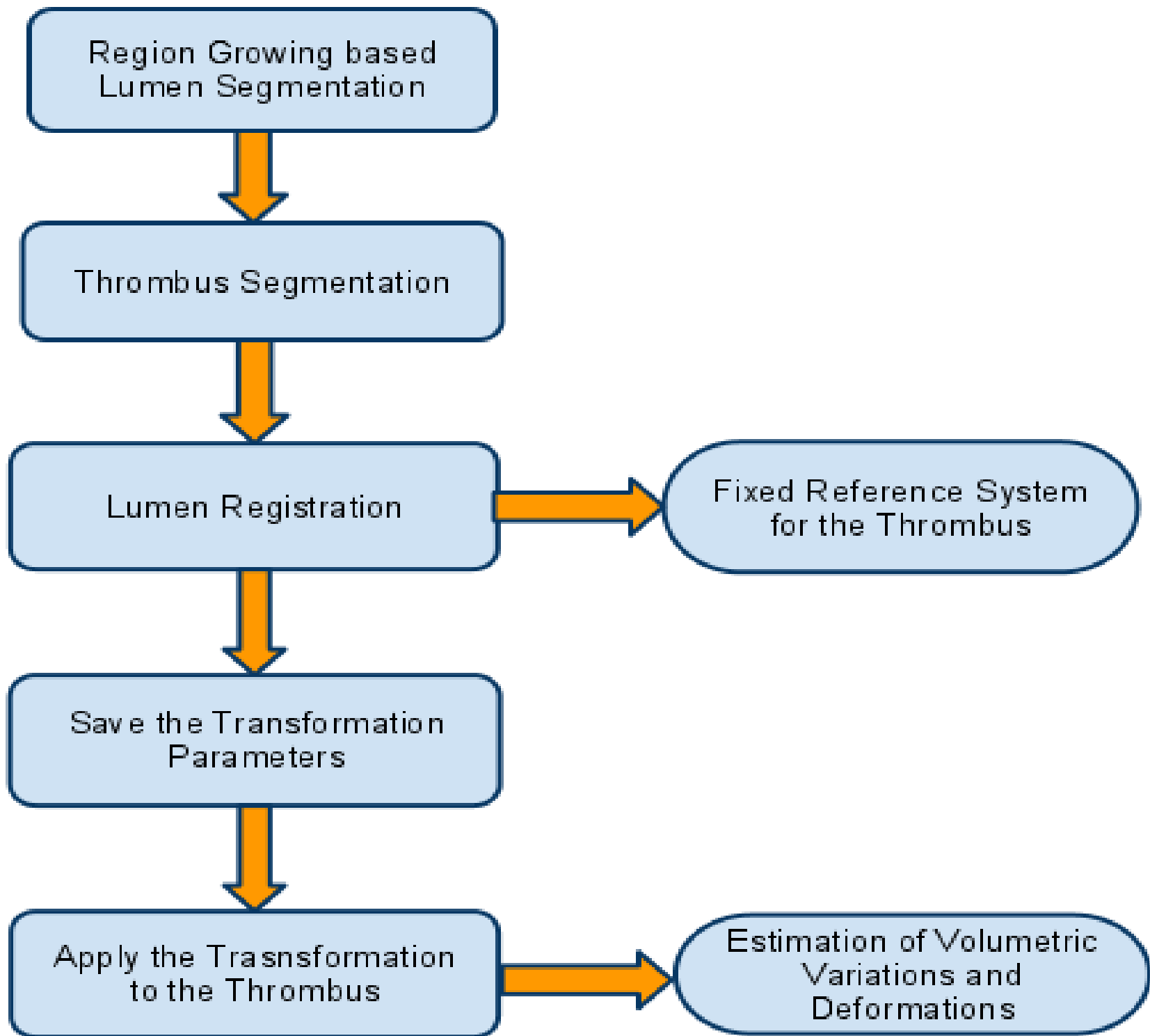
Lumen Registration

Save the Transformation
Parameters

Apply the Transformation
to the Thrombus

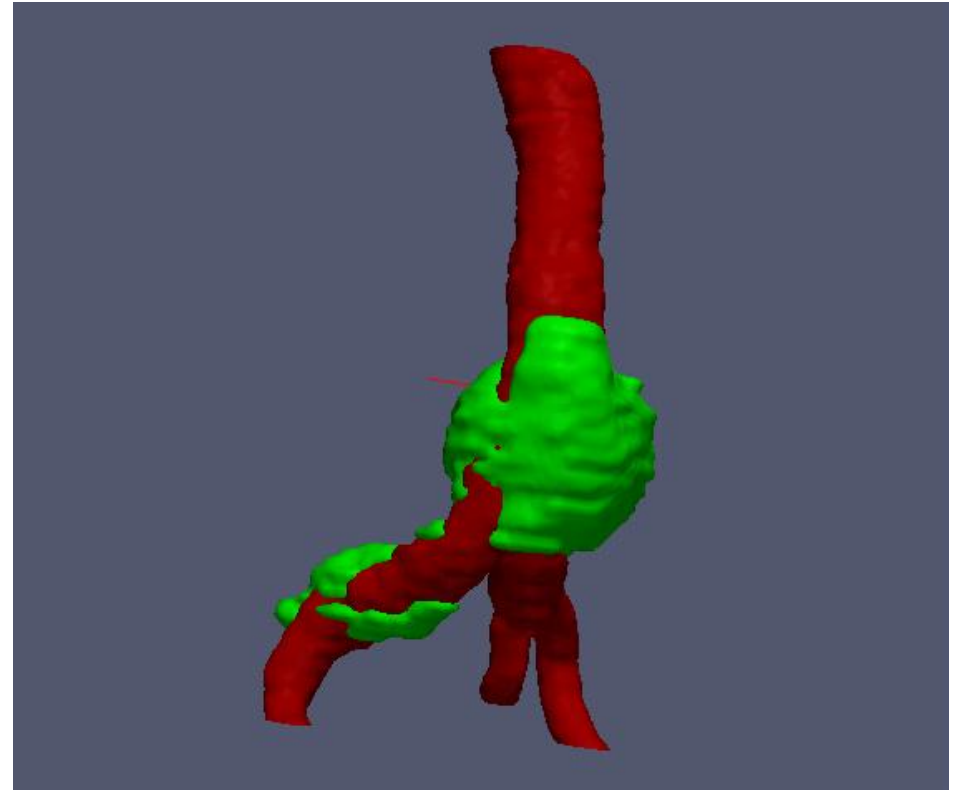
Fixed Reference System
for the Thrombus

Estimation of Volumetric
Variations and
Deformations



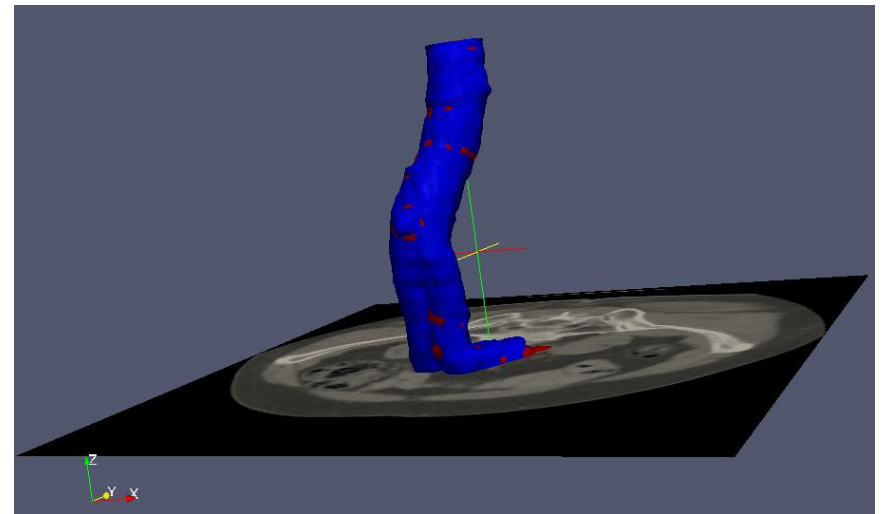
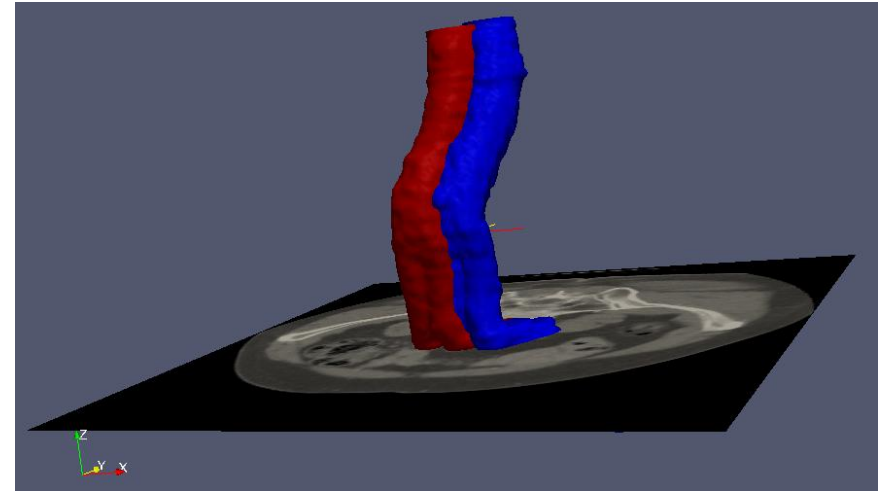
• Methods: segmentation

- Region Growing based Lumen Segmentation: At least a seed point placed in the lumen is required
- Centerline Extraction: a single point on the center-line is obtained for every slice
- Thrombus Segmentation: we calculate the internal and external radii of the thrombus



Lumen Registration

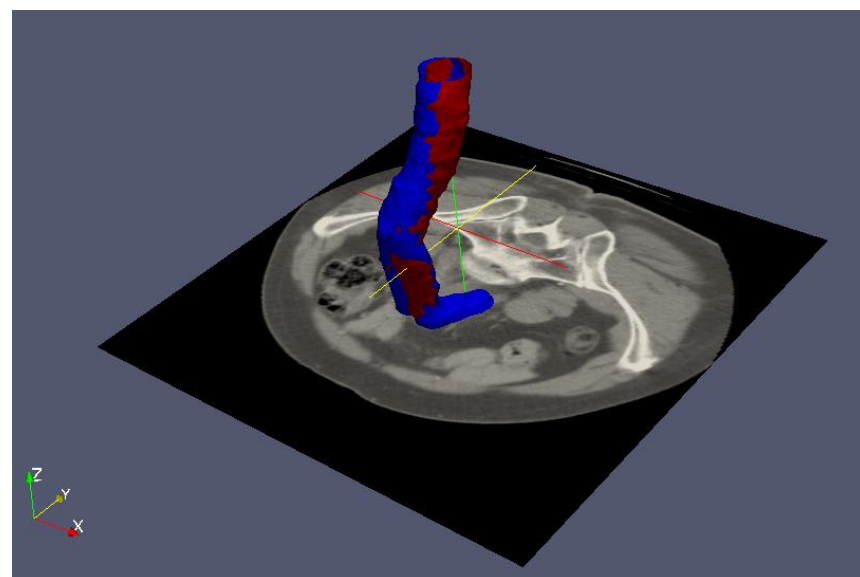
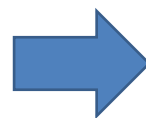
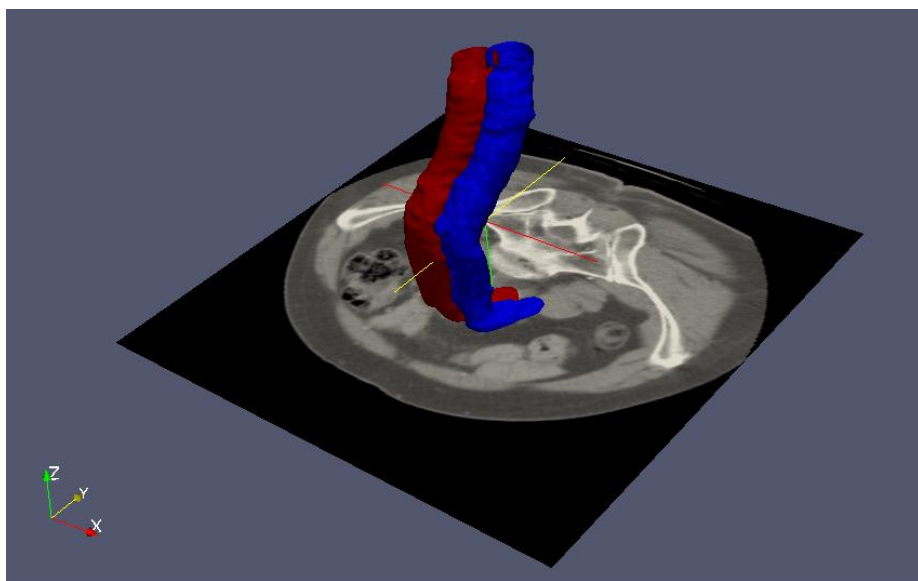
- Registration: the process of finding a spatial transform that maps points between two images.
- Our case: intra-subject, mono-modal
- Rigid, affine, deformable (B-Splines)
- Linear interpolator, Mutual Information metric, Regular Step Gradient Descent optimizer



Lumen Registration

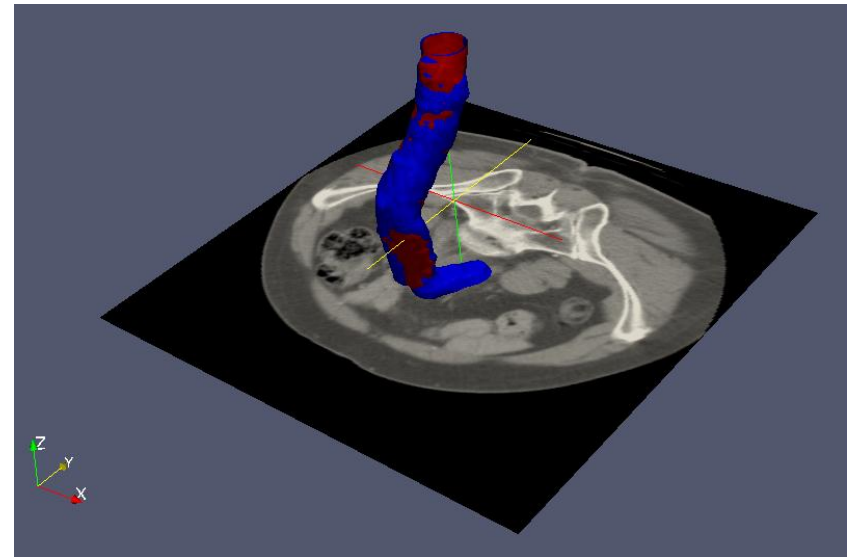
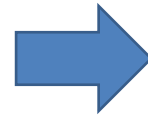
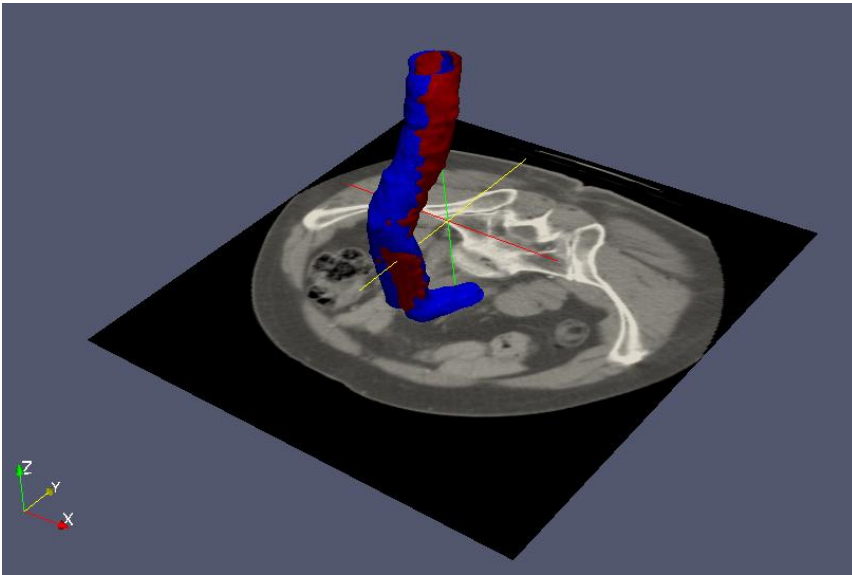
- Rigid Registration: This transformation can be presented as a rotation R followed by a translation t that can be applied to any point x in the image domain.

$$T_{\text{rigid}}(x) = Rx + t$$



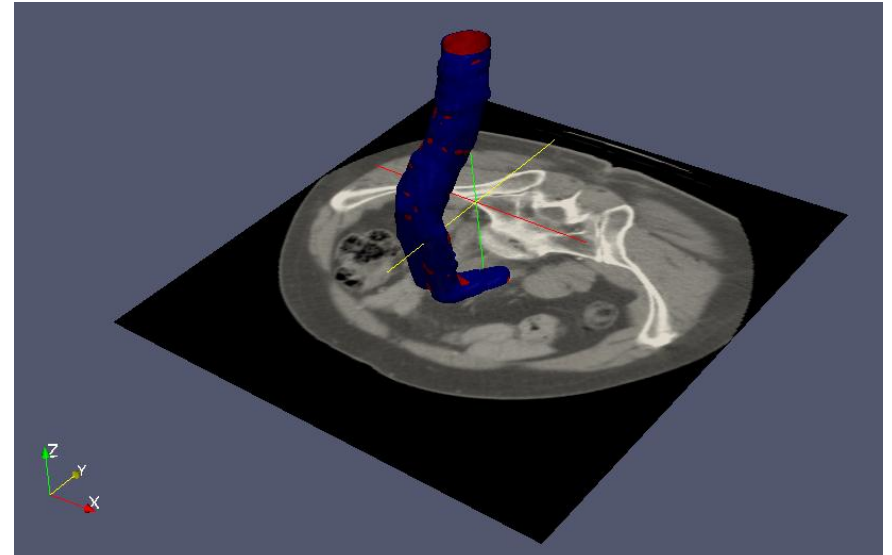
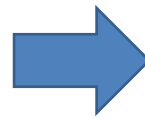
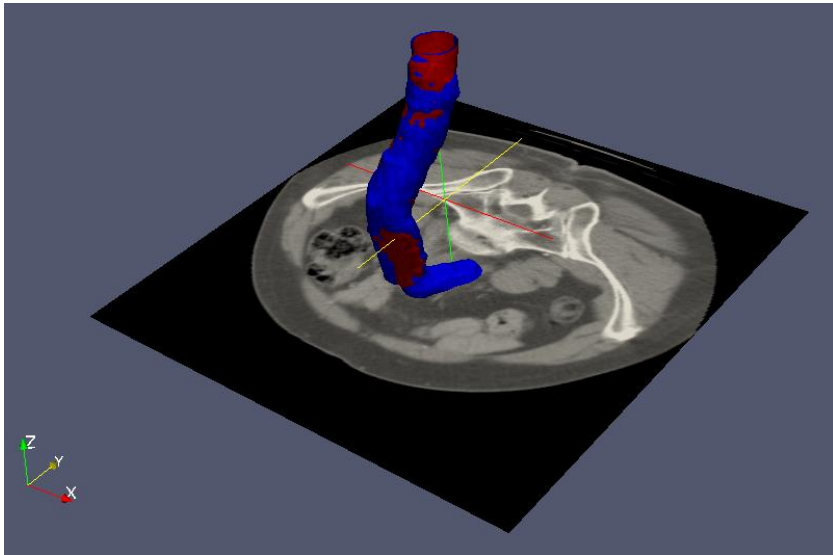
Lumen Registration

- **Affine Registration:** while a rigid transformation preserves the distances between all points in the object transformed, an affine transformation preserves parallel lines. This model has 12 degrees of freedom and allows for scaling and shearing



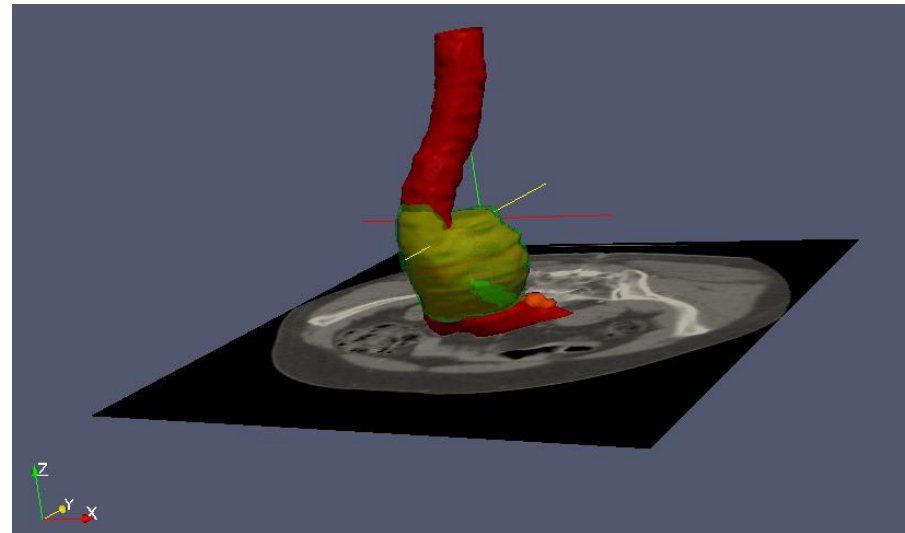
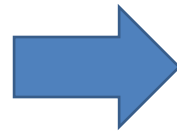
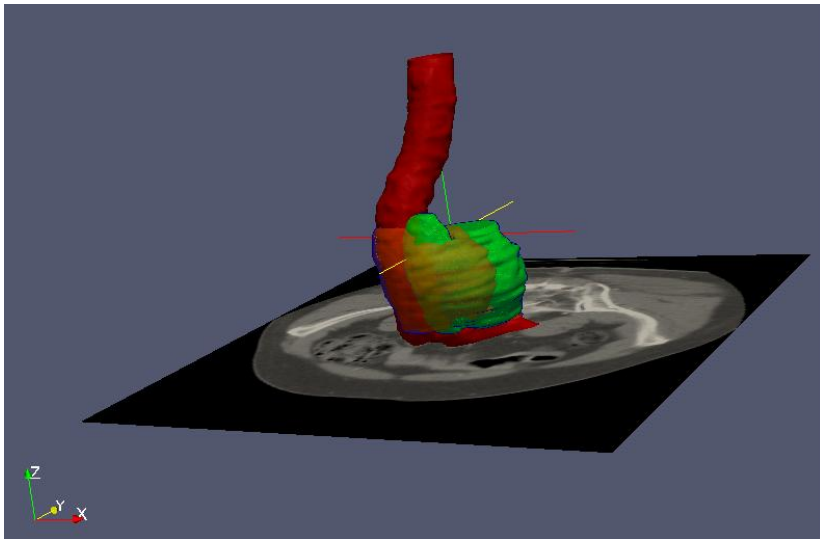
Lumen Registration

- Deformable Registration: we use Free Form Deformations (FFDs) based in locally controlled B-splines functions as a tool for modelling the lumen, as 3D deformable object.



Apply the Transformation to the Thrombus

- We save the parameters of the registration process
- We apply them to the thrombus of the moving image
- Then we can compare the volume changes and deformations of the thrombus



Evaluation of the registration quality

- We use two similarity metrics: the sum of squared intensity differences (SSD) and mutual information (MI).
- SSD is suitable when the images have been acquired through similar sensors.

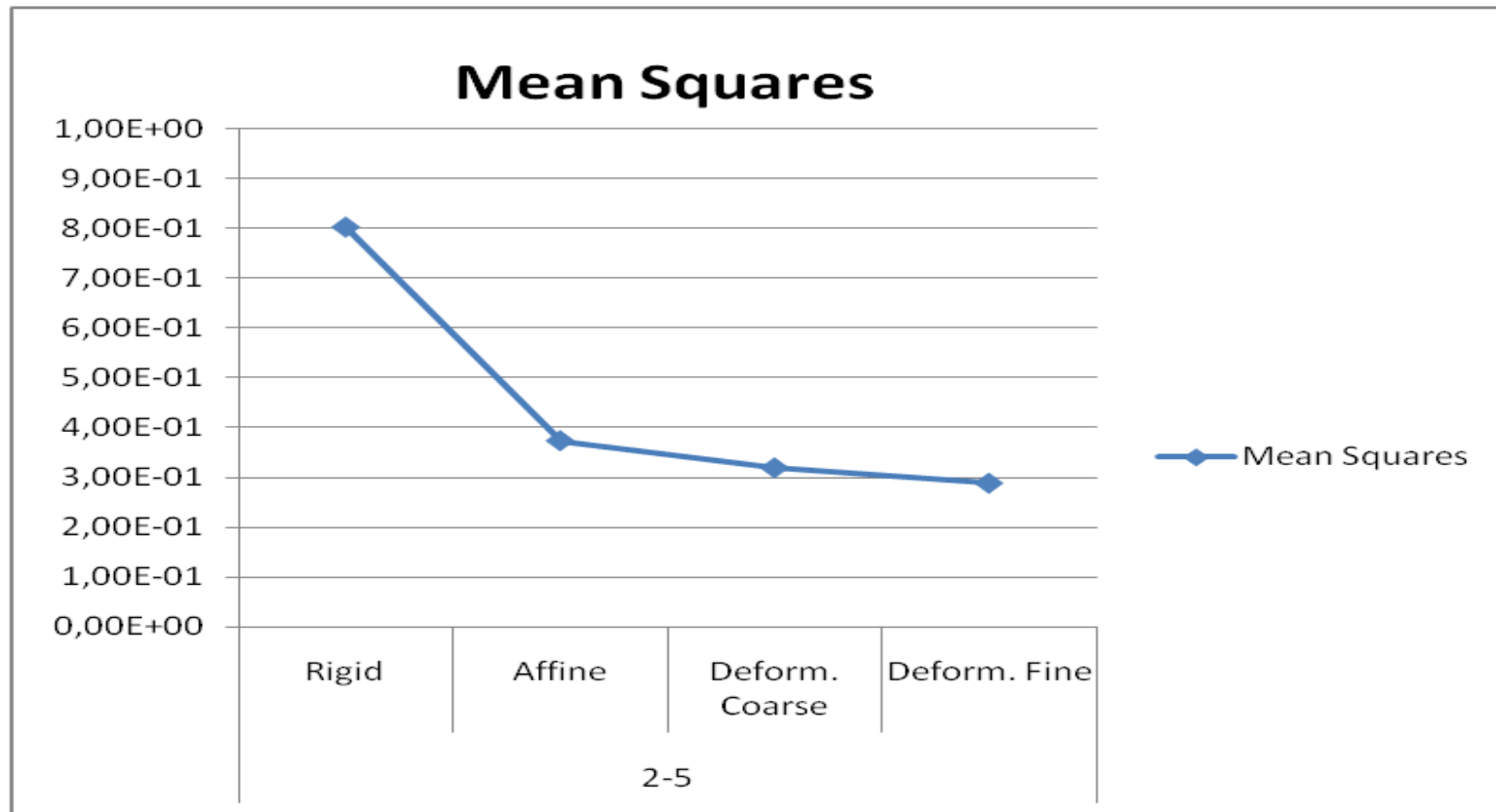
$$SSD = \frac{1}{N} \sum_{x_A \in \Omega_{A,B}^T} |A(x_A) - B^T(x_A)|^2$$

- Mutual information is a measure of how much information one random variable has about another.

$$I(A, B) = H(A) + H(B) - H(A, B)$$

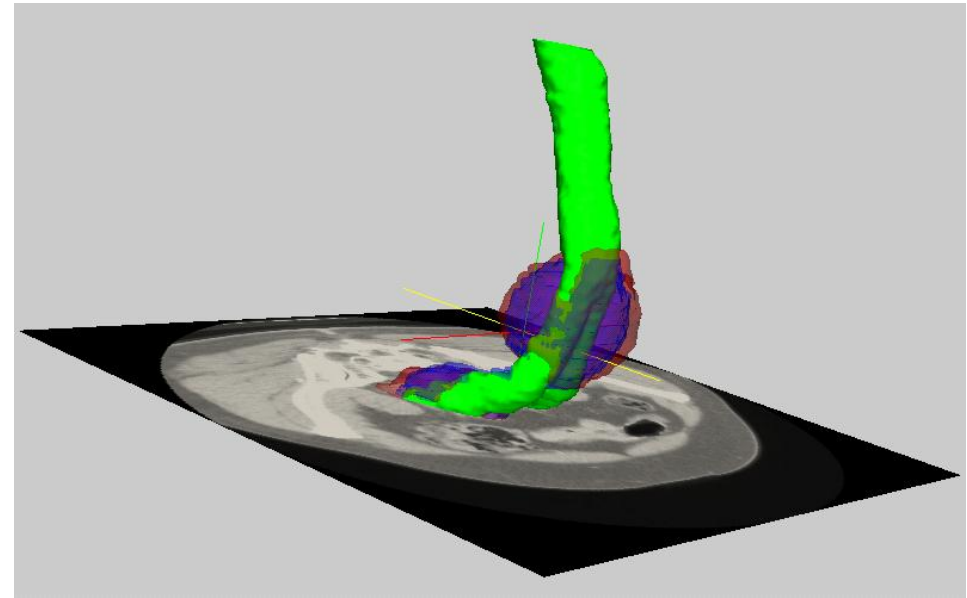
Evaluation of the registration quality

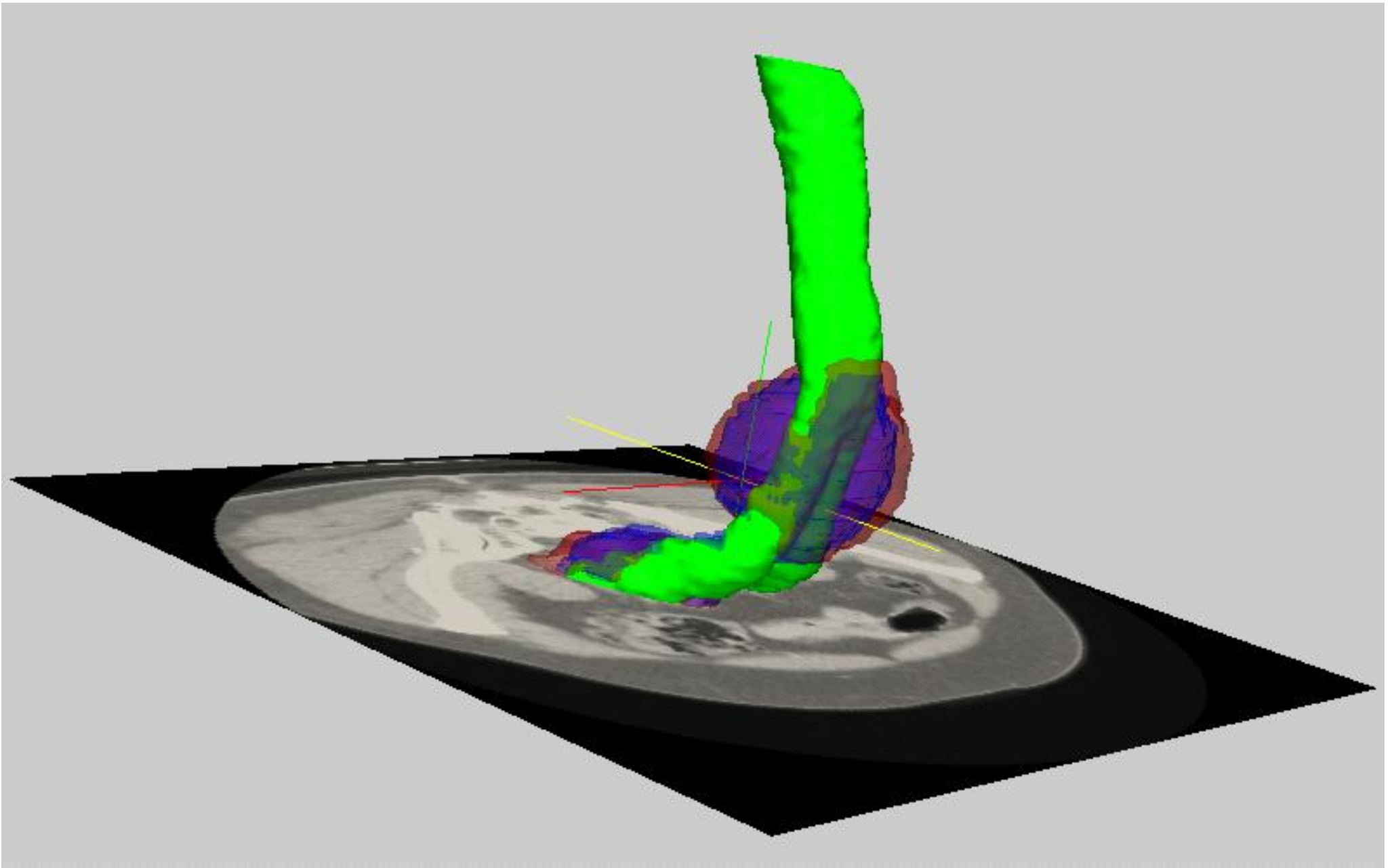
We have computed the mean squares and mutual information similarity metrics for the evaluation of the registration. A decrease of both metric is observed in the consequent registration methods.



Results

- We tested the approach with 3 patients—with 5 datasets each—treated with stent-graft devices
- The CT image stack consists of images with $512 \times 512 \times 354$ voxels resolution, and $0.725 \times 0.725 \times 0.8$ mm. spatial resolution.
- The time elapsed between different studies varies between 6 and 12 months.





Conclusions and Future Work

- We have developed a method that places the thrombi of different datasets of the same patient referenced to the lumen of the first dataset.
- The method allows detecting small changes in volume or deformation of the thrombus that may go unnoticed for radiologists while comparing individual slices of the same patient along time.
- In the future, we expect to obtain quantitative values of the changes in the thrombus.
- Support Vector Machines (SVM) to determine the evolution.
- Integrated into a more complex database

Acknowledgments

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