Stent Graft Change Detection after Endovascular Abdominal Aortic Aneurysm Repair

Josu Maiora[1] , Guillermo García[2], Arantxa Tapia[2], Iván Macía[3], Jon Haitz Legarreta[3], Céline Paloc[3], Manuel Graña[4] and Mariano de Blas[5],

[1] Electronics and Telecomunications Department, [2] Engineering Systems and Automatic Department, Technical University School, University of the Basque Country, Donostia-San Sebastián, Spain
{j.maiora, g.garcia, arantxa.tapia}@ehu.es

[3] Biomedical Applications Department, VICOMTech, Donostia-San Sebastián, Spain
{imacia, jhlegarreta, cpaloc}@vicomtech.org

[4] Computational Intelligence Group, Computer Science Faculty, University of the Basque Country, Donostia-SanSebastián, Spain
manuel.grana@ehu.es

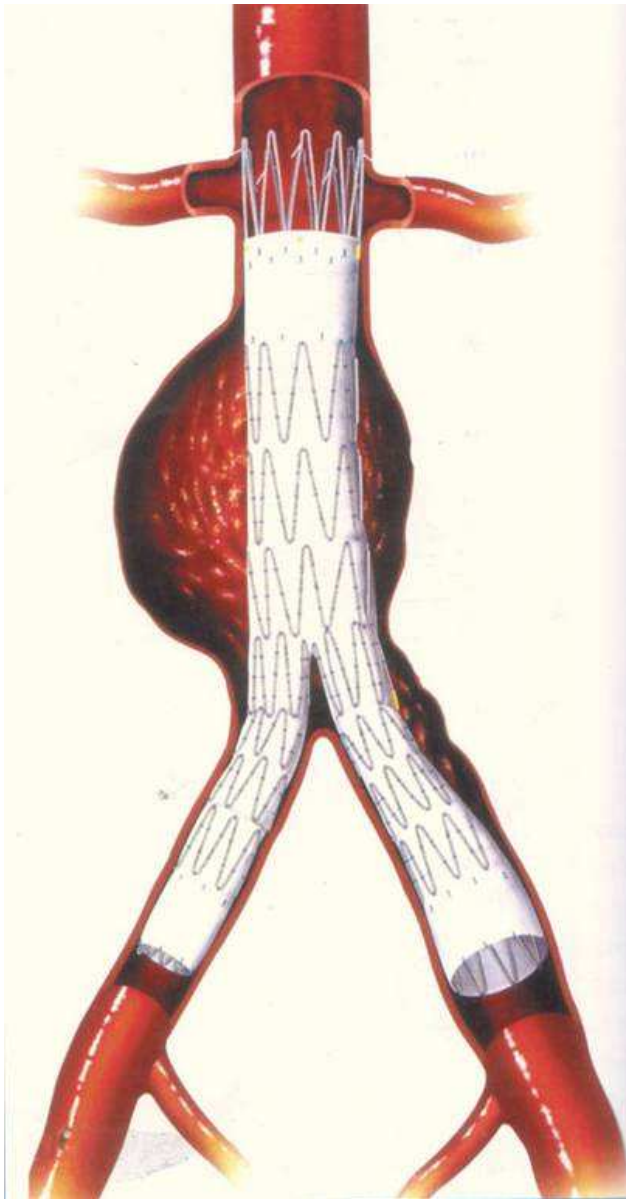
[5] Interventional Radiology Service, Donostia Hospital, Donostia-SanSebastián, Spain
mariano.deblasbravo@osakidetza.net

Outline

- Introduction
- Methods
  - Visualization
  - Segmentation
  - Registration
- Results
- Conclusions

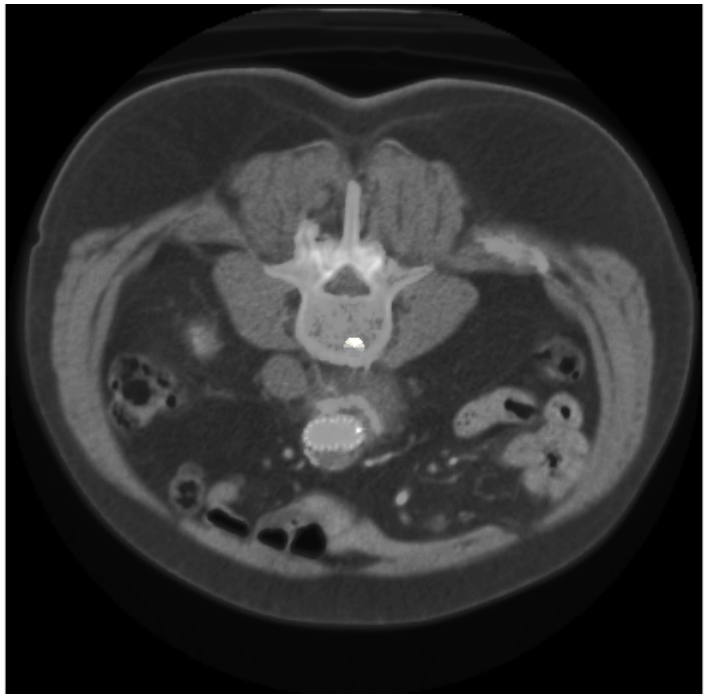
Introduction

- Abdominal Aortic Aneurysm is a focal dilation in the abdominal aorta
- EVAR: endovascular prosthesis insertion
- Postoperative follow-up required
- Expansion/presence of leakage: risk of rupture



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.

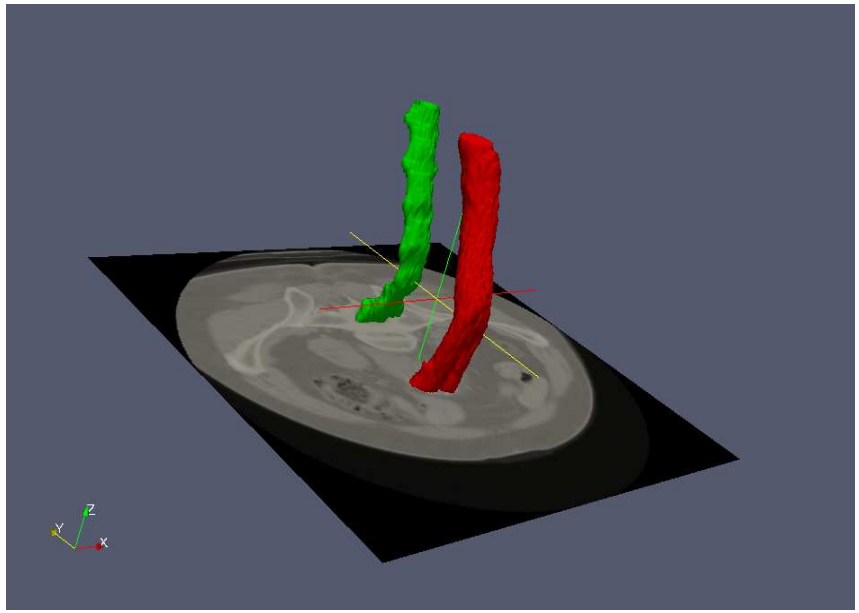


Introduction: our approach

- Estimation of the rigid motion of the stent relative to the spinal cord as well as its deformation.

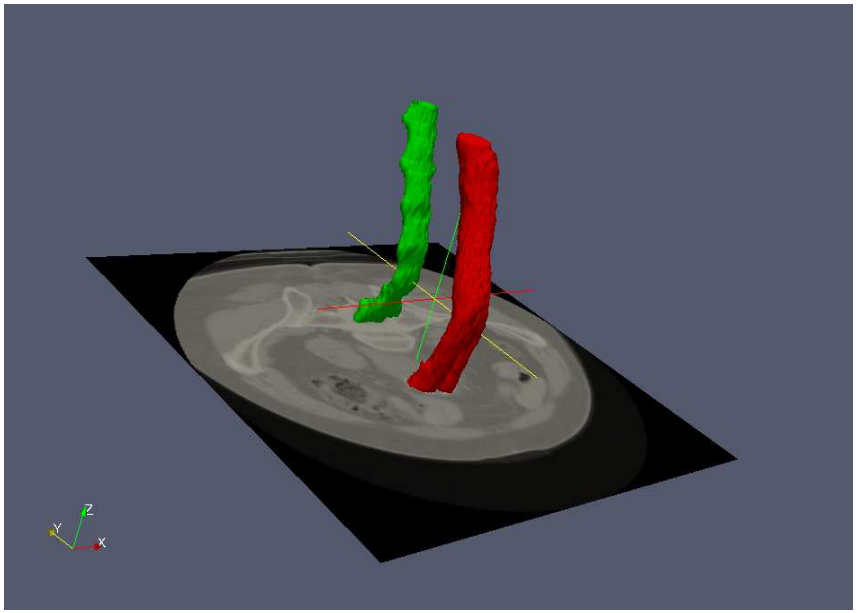
- Methods:
  - Visualization
  - Segmentation
  - Registration

- Integration in a medical image processing platform



Methods: visualization

- Visualization as 3D volumes with ITK and VTK based applications
- Metaimages are created from CT slices in DICOM format
- This process keeps the resolution and spacing of the original images.
- It will be used as input of the subsequent pipeline.



Methods: segmentation

- User Guided Level Set Segmentation
  - Image resampled into a volume with isotropic spacing (1,1,1)
  - ROI selection: spinal canal and stent graft (lumen)
  - Probability maps are computed applying a smooth lower and upper threshold
  - Place a seed in the spinal canal (lumen)
  - The contour evolves according to the following PDE

$$\frac{\partial}{\partial t} C(t,u,v) = F\vec{N}$$

  - We compute the external force F with the next stimation.

$$F = \alpha(P_{obj} - P_{bg}) + \beta k$$

Methods: registration

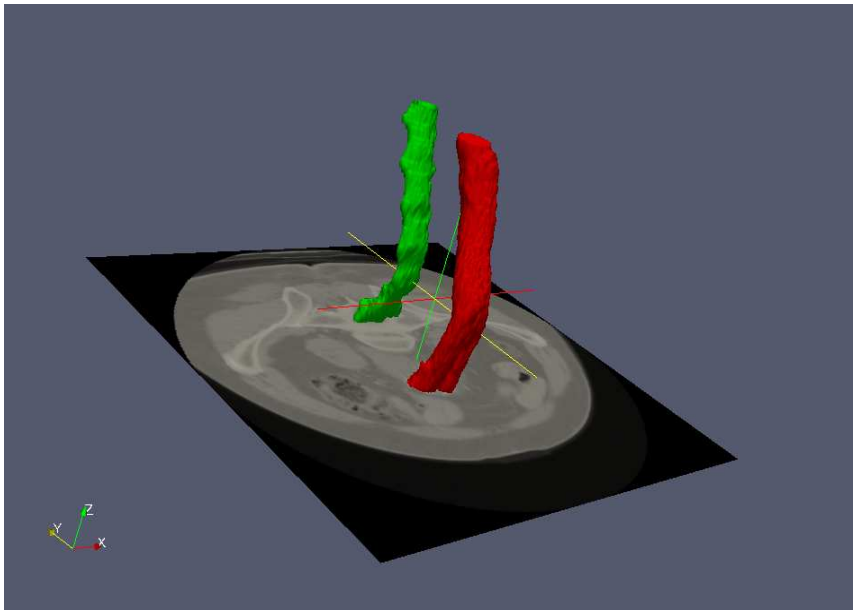
- The process of finding a spatial transform that maps points between two images.
- Our case: intra-subject, mono-modal
- Rigid, affine, deformable (B-Splines)
- Linear interpolator, Mutual Information metric, Regular Step Gradient Descent optimizer

Methods: registration

- Rigid registration of the spinal canal to fix the reference system
- Visualization of the migration
- Rigid registration of the stent graft
- Visualization of the deformation
- Deformable registration to correct the stent graft moving image

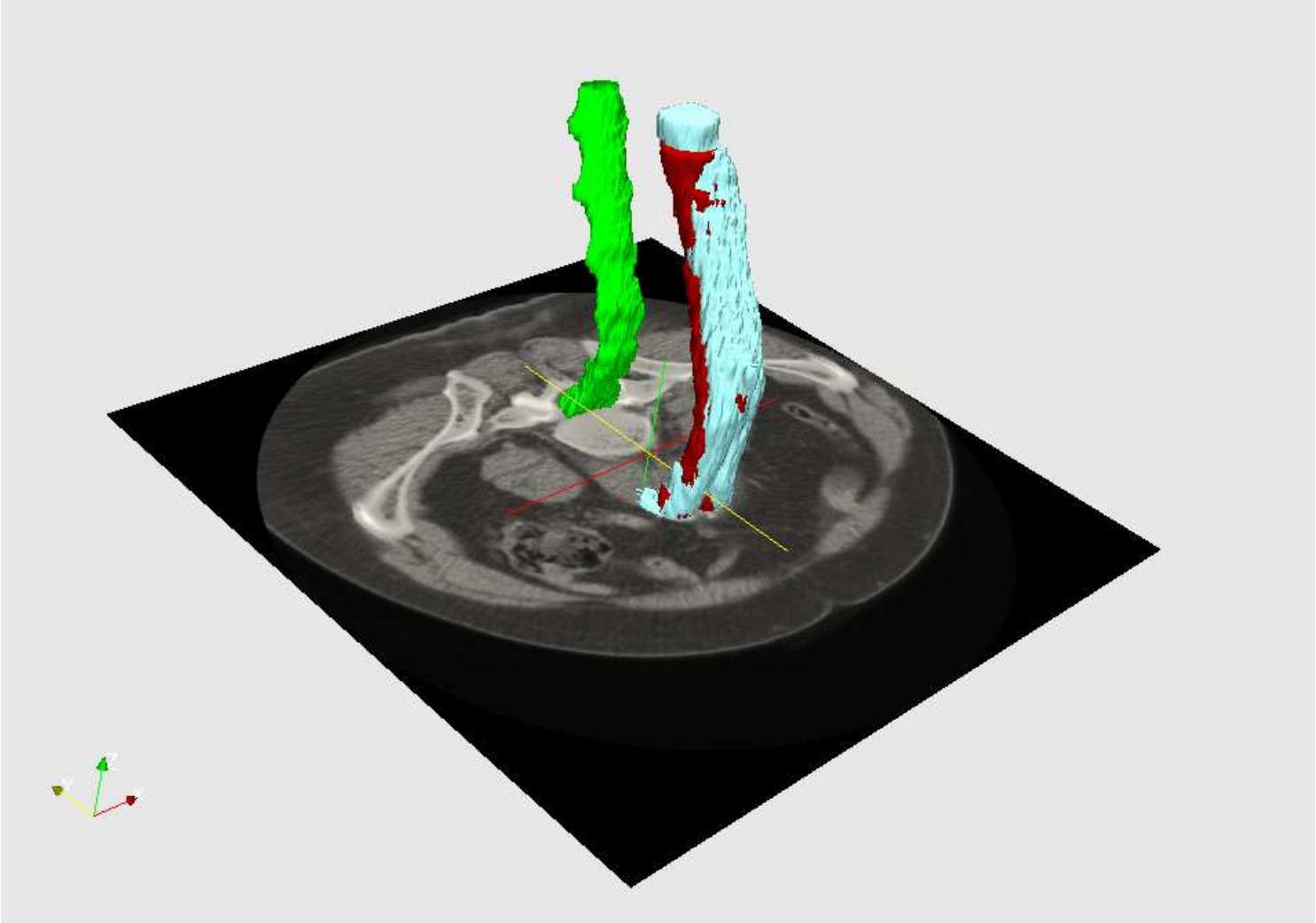
Results

- We tested the approach with patients treated with stent-graft devices
- The CT image stack consists of images with 512 x 512 pixels per slice, with a thickness of 3 mm and a x-y spacing of 0.684 mm and a number of 70 to 100 slices
- The time elapsed between different studies varies between 6 and 12 months.



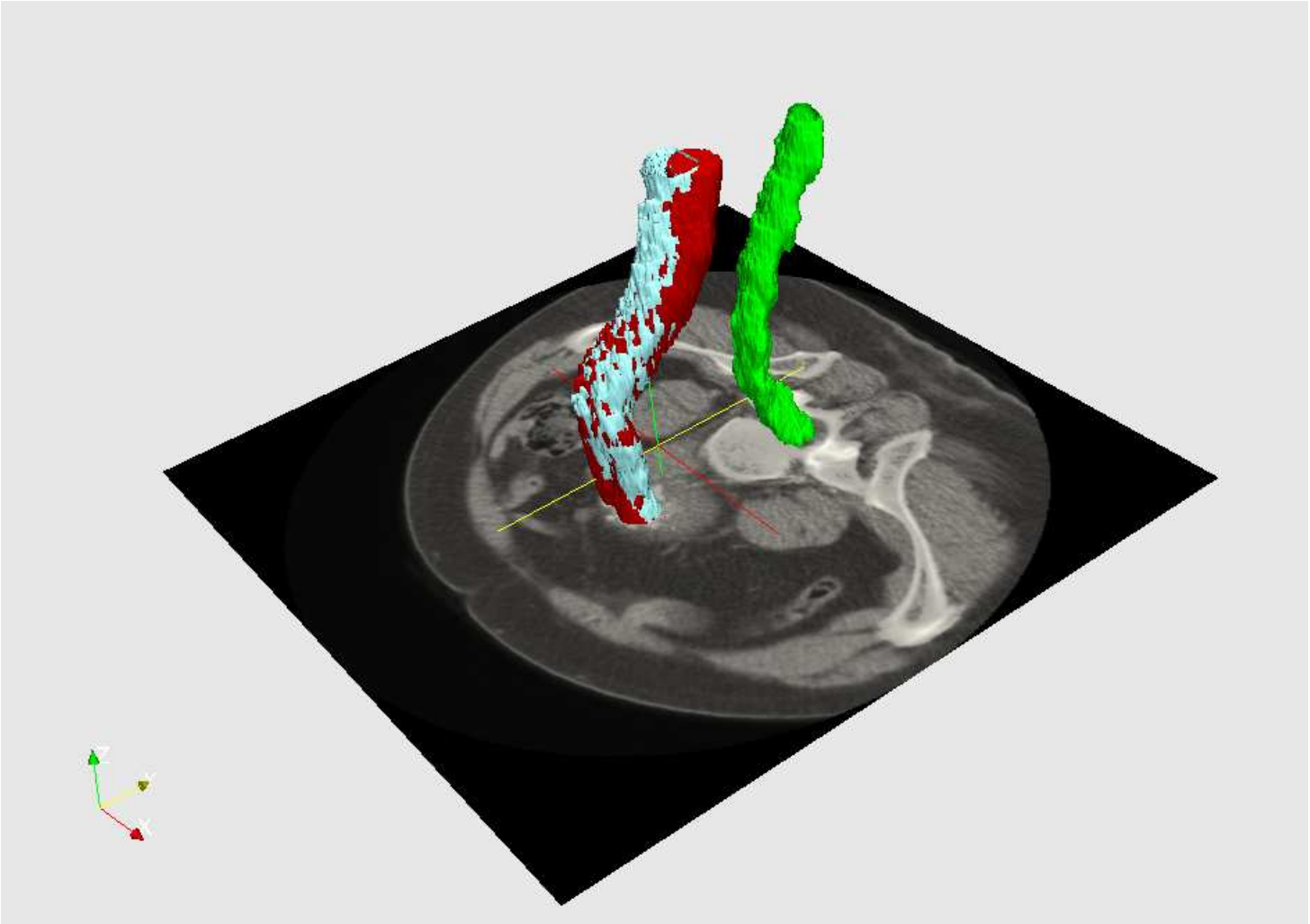
Results

After we register the spinal canal, we visualize the migration of the stent graft from one point in time to the next



Results

We can compare the stent-graft of two different studies after a rigid registration. Deformation is visualized.



Conclusions

- We have registered the spinal canal of different studies to place the patient in a single reference system
- The registration process is carried out over binary images improving on the works that perform registration over point sets, which always involve a greater loss of information.
- As future work, registering images from different studies from a given patient can provide us quantified values of the migration and deformation of the stent graft
- This could lead to a model that would predict the evolution of other patients and provide support for the decision
- This will be part of a more complex database where multiple information about the patients and monitored aneurysm will be available.

Acknowledgments

This work is sponsored and partially financed by the Basque Government through the INTEK Program.

We also thank the companies Bilbomatica and eMedica for their participation in this work.