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Grupo de Inteligencia Computacional

Classification of patients after Endovascular Repair based on image registration quality measures

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Outline

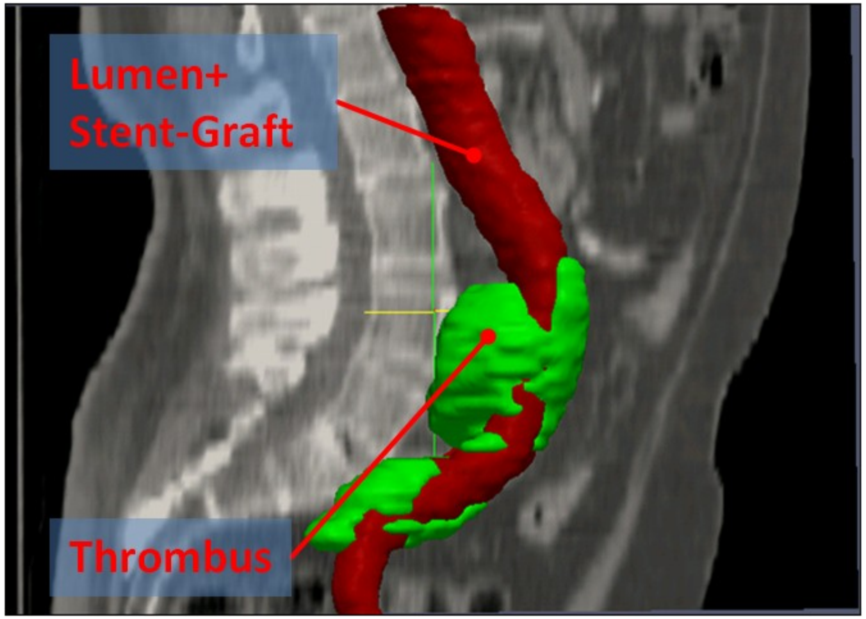
- Introduction
- Methods
  - Image Processing: Segmentation and Registration.
  - Neural Network Classification Algorithms
- Results
- Conclusions

Introduction

- Abdominal Aortic Aneurysms (AAA) is a focal dilation of the aorta in the abdominal region.

- The use of the endovascular prostheses for aneurysm repair (EVAR) has proven to be an effective technique to reduce the pressure and rupture risk of aneurysm

- The most widely used technique for EVAR monitoring is to obtain Computerized Tomography (CT) images of the abdominal region after an intravenous contrast agent has been injected



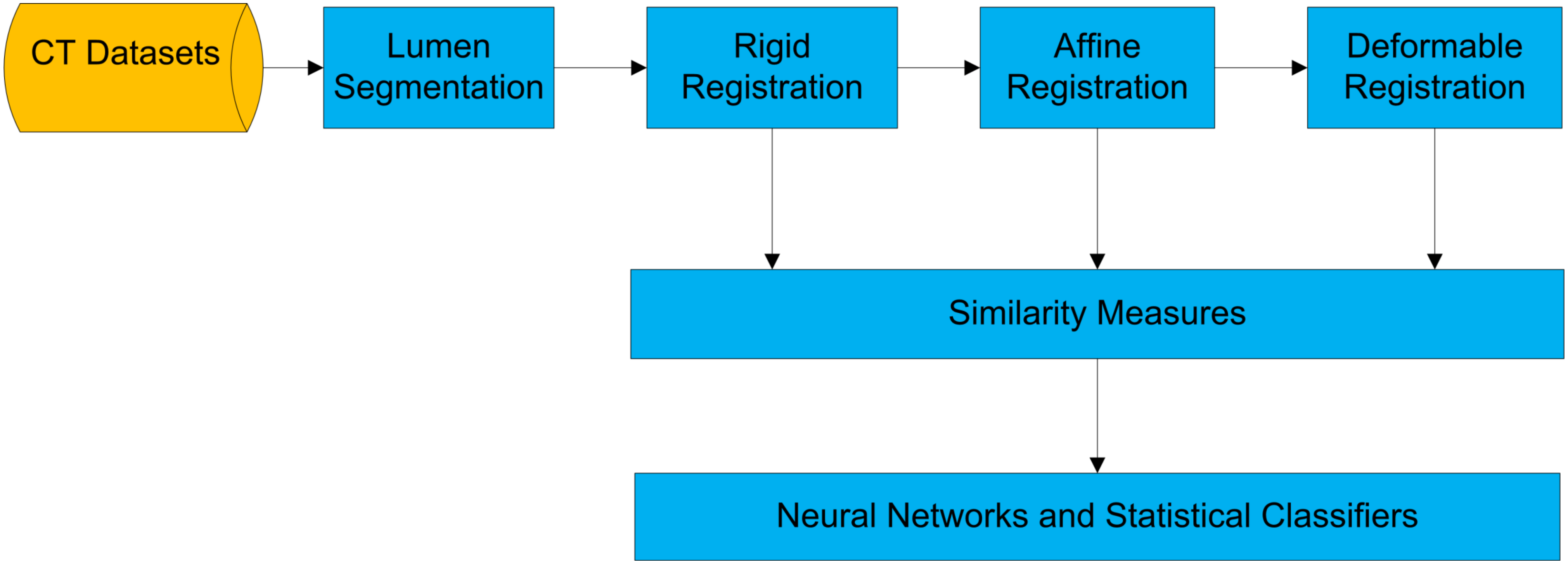
Introduction

- The aim of our work is to make an semi-automatic analysis of the AAA to monitor and track patients who underwent EVAR, allowing to classify their evolution as favorable or unfavorable.

- We calculate the similarity metrics after rigid, affine and deformable registration of the aortic lumen after EVAR and to construct a classifier to make a prediction.

- We test classification systems built using the standard SVM, with linear and non-linear (RBF) kernels, and some ANN architectures: Learned Vector Quantization (LVQ), Multi-Layer Perceptron (MLP), Radial Basis Function (RBF)

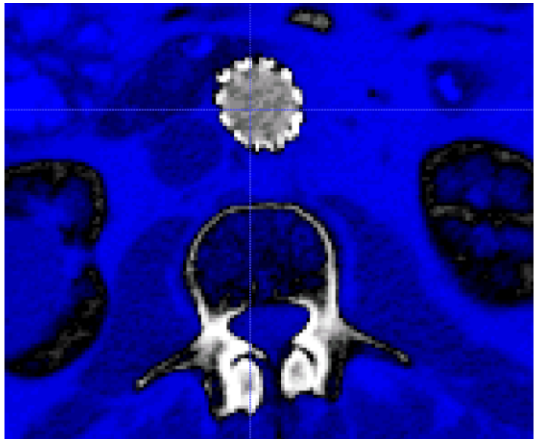
Methods

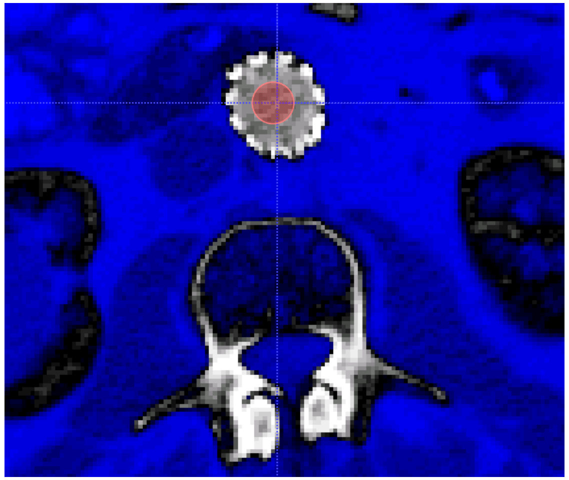

CT Datasets
Lumen Segmentation
Rigid Registration
Affine Registration
Deformable Registration
Similarity Measures
Neural Networks and Statistical Classifiers

Methods: Region Growing based Lumen Segmentation

- Preprocessing: probability maps are computed, by applying a smooth lower and upper threshold.

- We place a seed to initialize the evolving contour into the lumen and we establish the parameters that control the propagation velocity and curvature velocity.



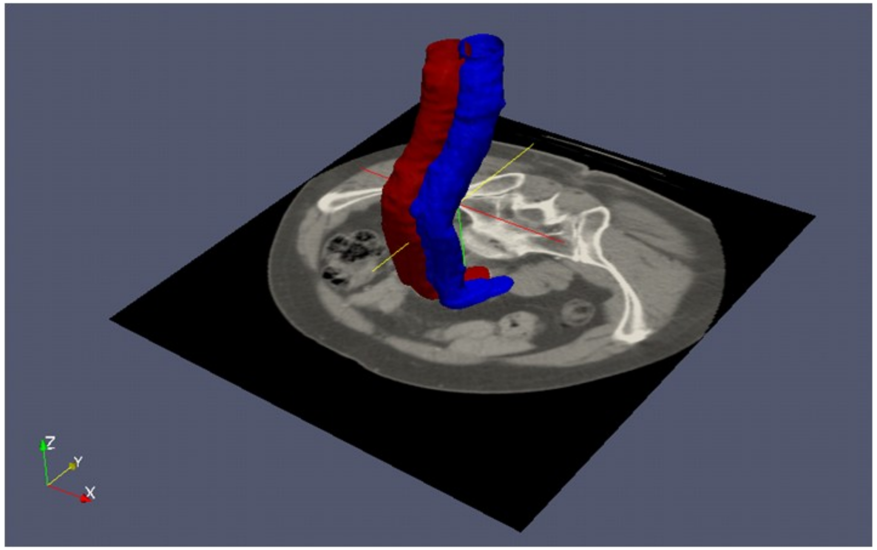


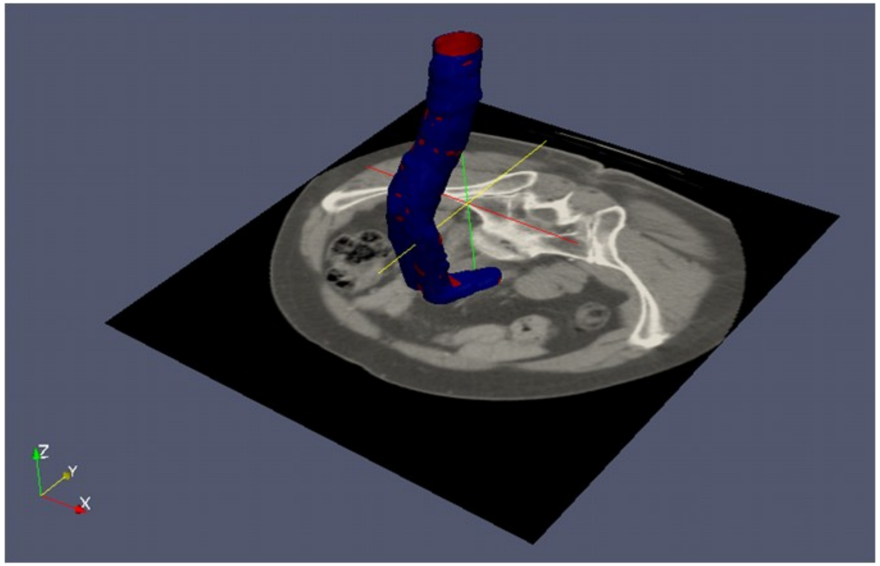
Methods: Registration

- A sequence of three registration steps is performed: rigid, affine and deformable (B-splines) registrations.

- The segmented lumen of the first study is considered as the fix image and the others are registered with respect to it.

- A linear interpolator, Mutual Information metric and Regular Step Gradient Descent Optimizer are used.





Methods: Classification

- Our aim is to classify the patients as those who have a favorable or unfavorable evolution.

- We test classification systems built using:
  - Standard SVM, with linear and non-linear (RBF) kernels.
  - ANN architectures:
    - ✓ Learned Vector Quantization (LVQ).
    - ✓ Multi-Layer Perceptron (MLP).
    - ✓ Radial Basis Function (RBF).

- The goal is to test the hypothesis that classification algorithms can discriminate between favorable and unfavorable evolution of patients who underwent an EVAR procedure.

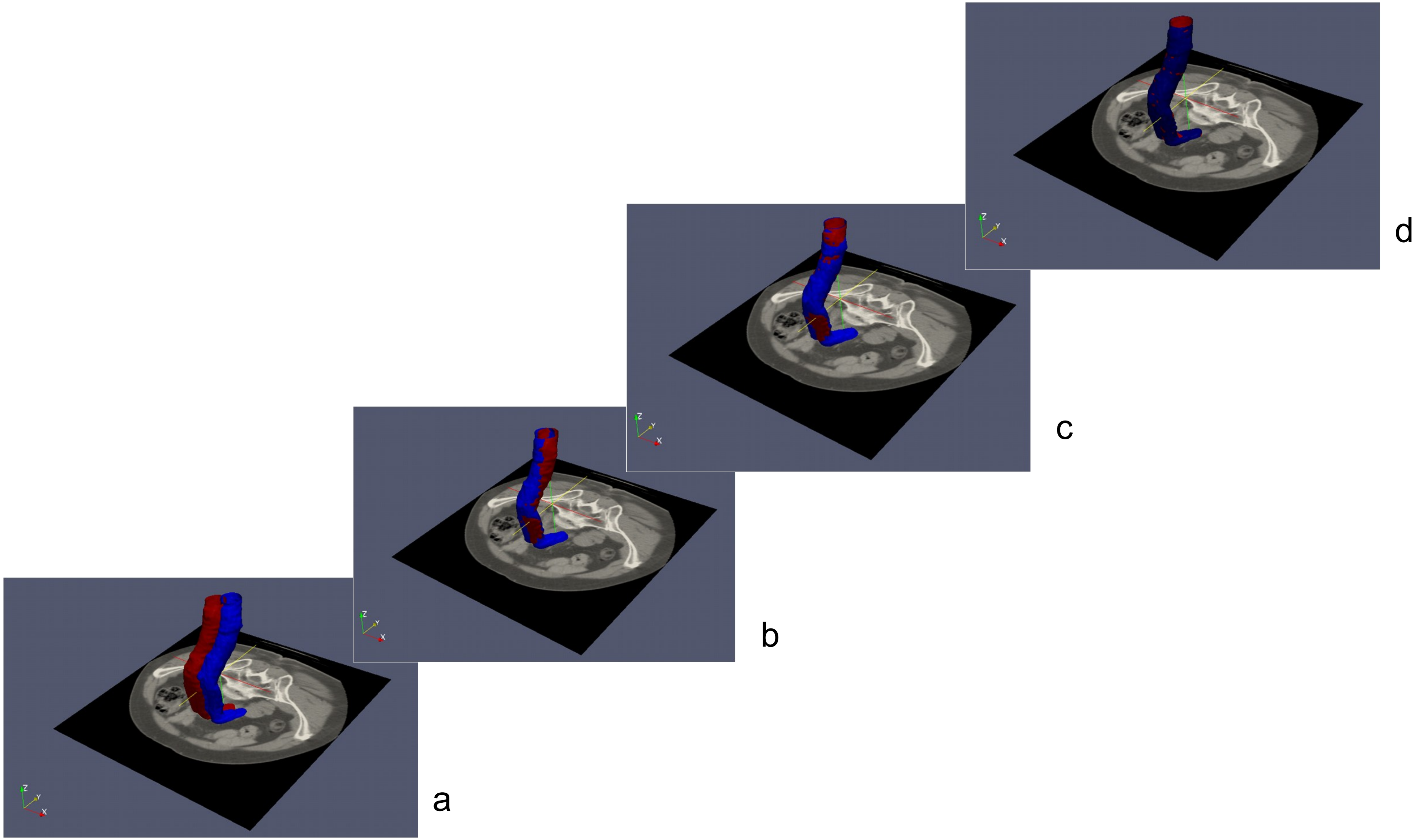
Results

- We have tested the approach with 15 datasets corresponding to 5 patients which have been treated with stent-graft devices

- The CT image stacks consists of datasets obtained from a LightSpeed16 CT scanner (GE Medical Systems, Fairfield, CT, USA) with 512x512x354 voxel resolution and 0.725x0.725x0.8 mm. spatial resolution. The time elapsed between different studies of the same subject varied between 6 and 12 months.

- 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 consecutive registration methods.

Results



Visualization of fixed and moving images of the lumen (a) before registration, (b)after rigid, (c) affine, and (d) deformable registration.

Results

- We build the input feature vectors with the values of the similarity measures after different registration modalities for each pair segmented lumens. So, we have 8 features for each registered image pair, 4 with the MSD metric and 4 with the MI.

- The average results of 10-fold cross-validation tests, are presented in Table 1

Classifier	Accuracy	AUC	RMSE
linear SVM	0.90	0.913	0.3162
rbf SVM	0.70	0.500	0.5477
MLP-BP	0.90	0.857	0.3535
RBF	1.00	1.000	0.0499
LVQ	0.80	0.7619	0.4472
LMT	0.70	0.643	0.4822
Random Forest	0.90	0.952	0.2569

Table 1

Conclusions

- Registering images from different datasets from a given patient can provide us quantified values of deformation of the stent-graft.

- The feature vectors have been built with the similarity measures of the segmented lumen after rigid, affine and deformable registration. The datasets of the patients have been previously validated by the medical team as having a favorable or unfavorable evolution.

- The proposed feature extraction is effective in providing a good discrimination between patients that can easily be exploited to build classifier systems predicting the evolution of other patients and provide support for the physician decision making.

Future works

- Further ongoing works with a more extensive database are addressed to confirm our conclusions in the framework of collaboration with a team of medical clinical experts.

- It would also be interesting to include as classification features other patient’s specific characteristics like gender, age, or if he/she is a smoker, diabetic...