

Hybrid Decision Support System for Endovascular Aortic Aneurysm Repair Follow-Up

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Jon Haitz Legarreta Gorroño

Researcher – eHealth and Biomedical Applications Department jhlegarreta@vicomtech.org





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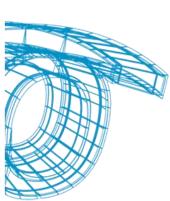
OUTLINE

- 1. Introduction
- 2. Objectives
- 3. System overview
- 4. Results and Discussion
- 5. Conclusions and Future Work





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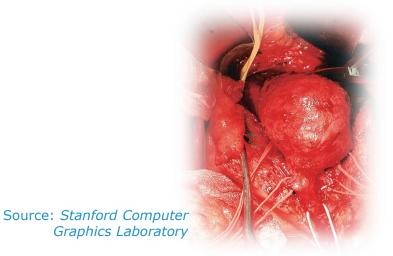
. Introduction

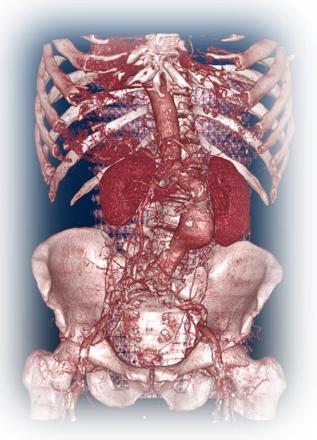
- 2. Objectives
- 3. System overview
- 4. Results and Discussion
- 5. Conclusions and Future Work

What is an abdominal aortic aneurysm?

An overview of the medical problem (I)

An abdominal aortic aneurysm (also \mathbf{O} known AAA) is a localized as dilatation (ballooning) of the abdominal aorta, exceeding the normal diameter (50% increase over normal aorta diameter or 3 cm of enlargement).





AAA affected patient. Volume render



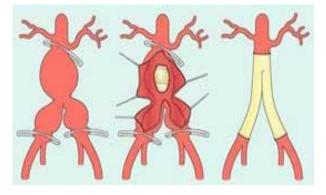
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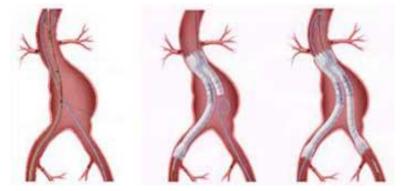
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Surgical repair of AAAs

- **Natural behaviour is to grow larger**.
- Survival rate to rupture is less than 10%.
- O Two surgical repair techniques:
 - **Open Repair (OR)**: The weakened (ballooned) portion of the aorta is replaced with a stent graft that is matched to the normal aorta and sewn in place.
 - □ **Endovascular Aneurysm Repair (EVAR)**: A stent graft is inserted through the femoral arteries in order to exclude the bulge from blood circulation. A catheter serves as a guide.



Source: Hallet et al.: *Comprehensive Vascular and Endovascular Surgery*, 2004 Elsevier Ltd.



AAA treatment with a modular Quantum (CORDIS, Johnson & Johnson) stent graft



1. Introduction

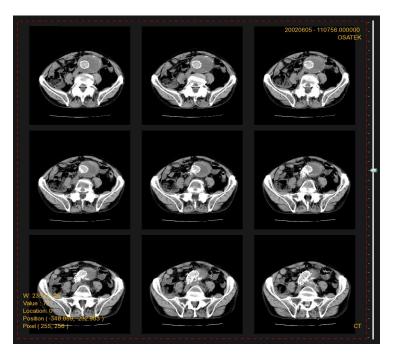
- 2. Objectives
- 3. System overview
- 4. Results and Discussion
- 5. Conclusions and Future Work



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Where do the biomedical engineers come up?

- A successful outcome of EVAR means bulge shrinking; after EVAR AAAs may shrink or **may not.**
- O Screening is **necessary.**



EVAR undergone AAA affected patient. 3x3 mosaic view. CT imaging



I. Introduction

- 2. Objectives
- 3. System overview
- 4. Results and Discussion
- 5. Conclusions and Future Work

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One leak

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Where do the biomedical engineers come up?



What is an endoleak or leak?



Source: radswiki.net

I. Introduction

- 2. Objectives
- 3. System overview
- 4. Results and Discussion
- 5. Conclusions and Future Work
- As many as 36% of patients with bulge growth do not show leaks (EUROSTAR record <u>http://www.eurostar-online.org</u>).
- Only the presence of leaks and the size of the aneurysm are taken into account for evolution assessment.







Objectives

- The development of an integrated hybrid platform which encompasses
 - Heterogeneous data sources
 - Visualization tools
 - Segmentation and registration tools
 - □ Aneurysm morphometry information

1. Introduction

2. Objectives

- 3. System overview
- 4. Results and Discussion
- 5. Conclusions and Future Work

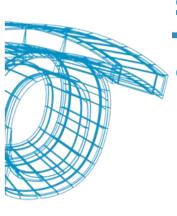
in order to build a system capable of proposing a computational process/model to predict EVAR outcome.

Aneurysm rupture risk prediction after EVAR procedure





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System components

- 3 stages
 - Pre-operative
 - □ Intra-operative
 - Post-operative
- O 5 subsystems
 - Segmentation system
 - Endoleak detection system
 - □ Registration and visualization system
 - □ Texture analysis
 - □ Risk prediction by *a priori* knowledge

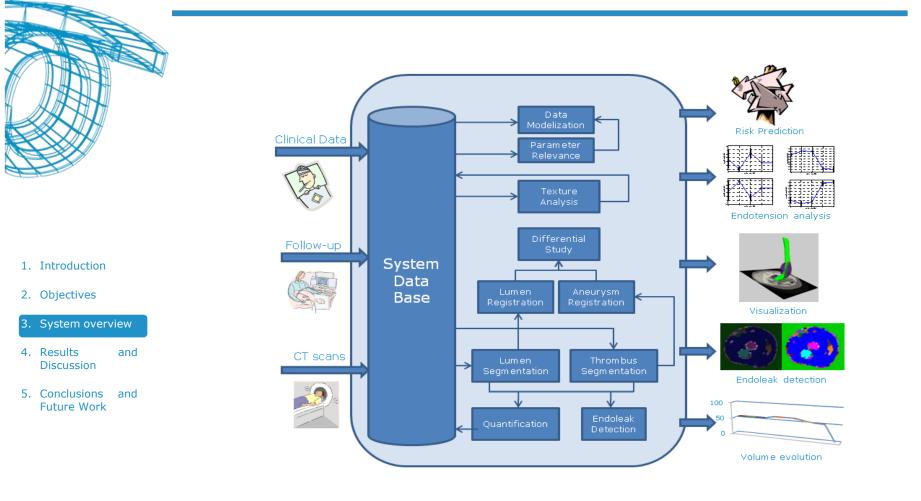


- 1. Introduction
- 2. Objectives
- 3. System overview
- 4. Results and Discussion
- 5. Conclusions and Future Work



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System components



System components





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• Input Data

- □ EVAR undergone patients' data
- □ Patients are considered to belong to one among three groups:
 - Favorable evolution
 - Unfavorable evolution with visible endoleaks
 - · Unfavorable evolution without visible endoleaks

1. Introduction

2. Objectives

3. System overview

- 4. Results and Discussion
- 5. Conclusions and Future Work

• A Web-based information system centralizes data related to the presence and evolution of EVAR-treated AAAs.

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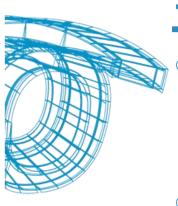


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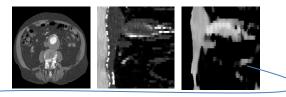
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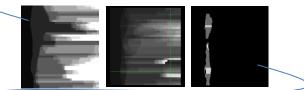


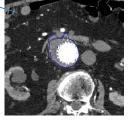
Segmentation subsystem

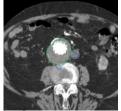
- **Interest**: automatically determine the boundaries of the (thrombus of the) AAA
 - Dimensions of the aneurysm
 - □ AAA evolution at a glance
- O **Difficulty**: thrombus boundaries are ambiguous at some points
- O Premise: contrast-enhanced CT
- 1. Introduction
- 2. Objectives
- 3. System overview
- 4. Results and Discussion
- 5. Conclusions and Future Work

- O Method
 - Semi-automated 3D radial model
 - □ First step: lumen segmentation
 - □ Second step: centerline extraction
 - □ Third step: thrombus segmentation





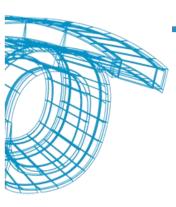






Thrombus segmentation process





Endoleak detection

- **Interest**: main known cause for aneurysmatic bulge growth after EVAR.
 - Detection is based on visual inspection of CT scans
 - □ Time consuming
- O Premise: contrast-enhanced CT
- O Method:
 - Detection of type II endoleaks
 - Based on a Multilayer Perceptron (MLP) Artifical Neural Network (ANN)
 - □ Input: output of the segmentation subsystem
 - □ AAA labelling using a Topological Grayscale Watershed Transform
 - □ Feature extraction and correlation analysis in order to get a reduced dimensionality
 - □ The MLP takes the reduced version of the vector and determines whether a connected component belongs to a type II endoleak



2. Objectives

1. Introduction

- 3. System overview
- 4. Results and Discussion
- 5. Conclusions and Future Work





Registration and visualization

- **Interest**: visualization of a given AAA along the time in the same scene.
- O Method:
 - □ A medical imaging visualization tool
 - □ Incorporates a DICOM explorer
 - Incorporates segmentation
 - Incoporates registration

- 1. Introduction
- 2. Objectives
- 3. System overview
- 4. Results and Discussion
- 5. Conclusions and Future Work





AAA visual analysis framework







Texture analysis

- **Interest**: discovery of the mechanism of growth of an AAA in the absence of endoleaks.
 - Medical team's hypothesis

O Method:

- □ Starting point: ground-truth classification
 - Favorable evolution
 - Unfavorable evolution with visible endoleaks
 - Unfavorable evolution without visible endoleaks

2. Objectives

1. Introduction

- 3. System overview
- 4. Results and Discussion
- 5. Conclusions and Future Work

- Statistical texture analysis based on Gray Level Spatial Dependency Matrix (GLSDM)
- □ Parameters' variance is compared in order to classify a patient







Risk prediction by a priori knowledge

- **Interest**: build a Clinical Decision Support System (CDSS).
 - □ CDSS on the need of reintervention
 - Pre-operative evaluation: which intra-operative parameters have an impact on the evolution?
 - □ Follow-up evaluation: which follow-up parameters have an impact on the evolution?

O Method:

- □ Statistical modelling of clinical information
- □ First step: statistical (manual) variable selection/filtering
- Second step: Artificial Neural Network (ANN) to analyze nonlinear data



1. Introduction

2. Objectives

3. System overview

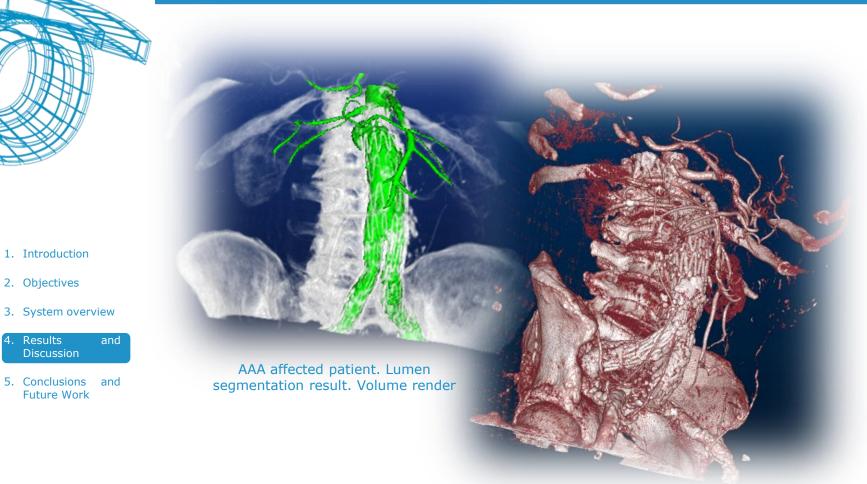
- 4. Results and Discussion
- 5. Conclusions and Future Work

Results and Discussion



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Results and Discussion



AAA affected patient. Volume render



4.

Results and Discussion



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Results and Discussion

- **O** Segmentation algorithm
 - □ Feasibility of the scheme
 - Reasonable computational time
 - □ Stability issues to be resolved
- O Endoleak detection
 - □ An average of 95% correctly classified labels for type II endoleaks
- Registration and visualization
 - Medical image viewer adapted to AAA visual analysis
 - AAA evolution at a glance
 - Texture analysis
 - □ Patients can only be split into favorable and unfavorable evolution
 - Multivariable analysis (Risk prediction by *a priori* knowledge)
 - □ Little results, although some reflect the ground truth



Discussion

1. Introduction

2. Objectives

Results

5. Conclusions and Future Work

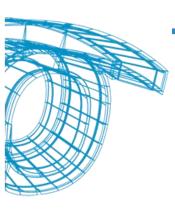
3. System overview

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Conclusions and Future Work

• First steps towards a hybrid computer aided system to help in AAA evolution assessment after EVAR.

O Conclusions

- □ New segmentation scheme
- □ Semi-automatic type II endoleak classification
- □ Hybrid approach

1. Introduction

- 2. Objectives
- 3. System overview
- 4. Results and Discussion
- 5. Conclusions and Future Work

- **O** Future Work
 - □ Curved Planar Reconstruction
 - Improvement of segmentation scheme
 - Quantification of algorithms' accuracy
 - □ Validation and integration into the services' workflow
 - □ Surgical planning?







Special thanks to the whole team

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20

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