Análisis automático de estructuras tubulares

Aplicaciones en enfermedades de aorta

Tahoces PG, Álvarez L, Trujillo A, Cuenca C, González E, Esclarín J, Gómez L, Mazorra L, Alemán-Flores M, Carreira J

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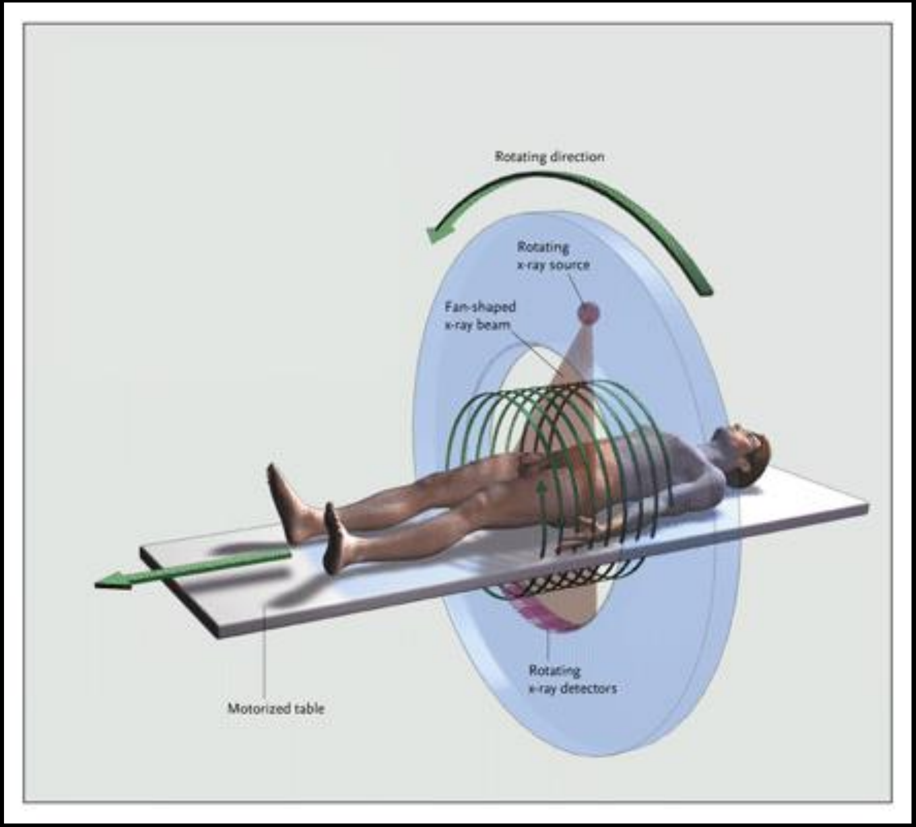
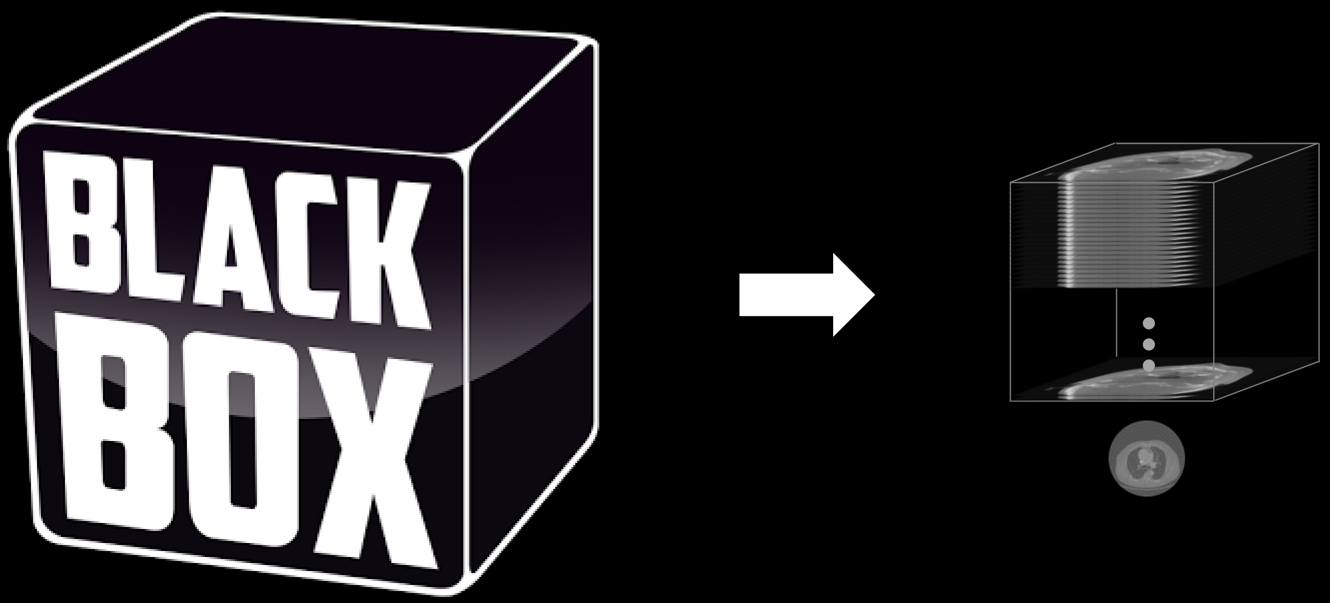
Introduction

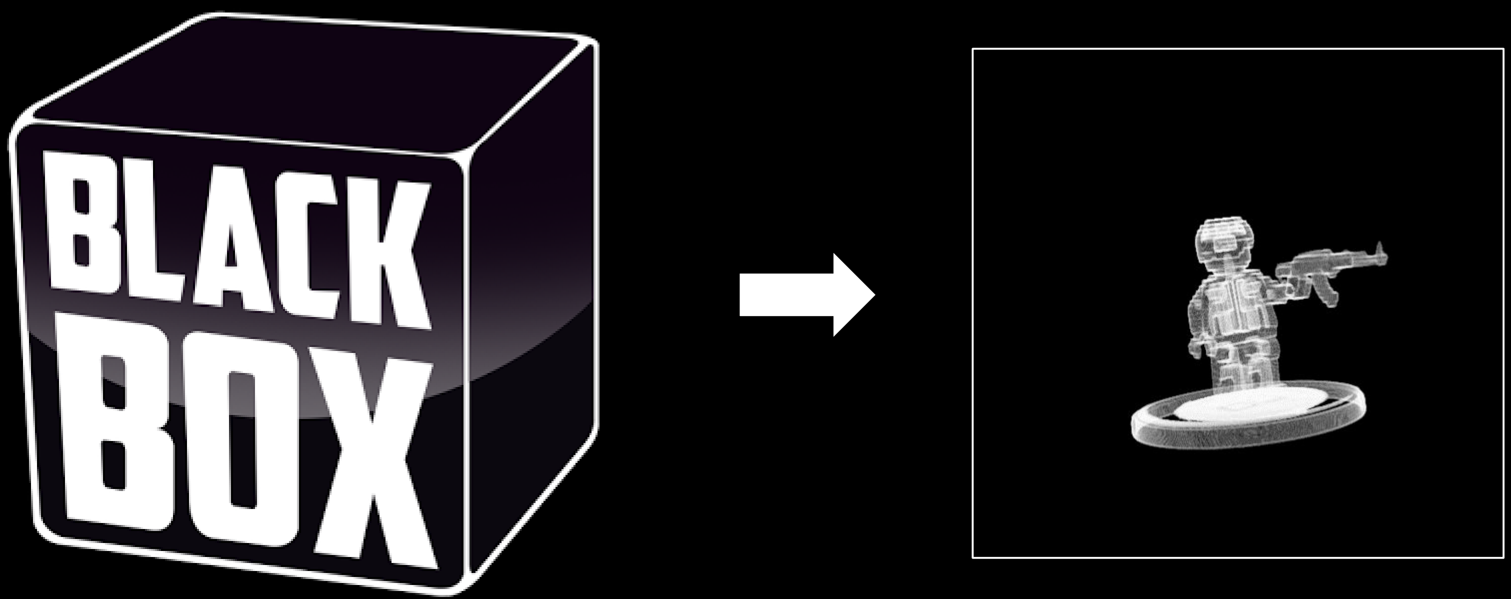
MDCT → Provides isotropic 3D images, opening the door to the image as a quantitative tool.



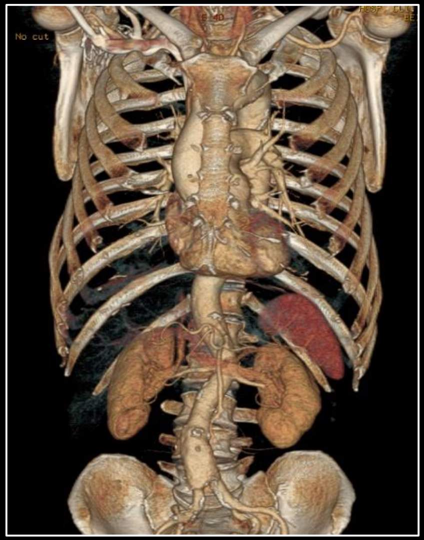
Introduction



Introduction



The Aorta Case



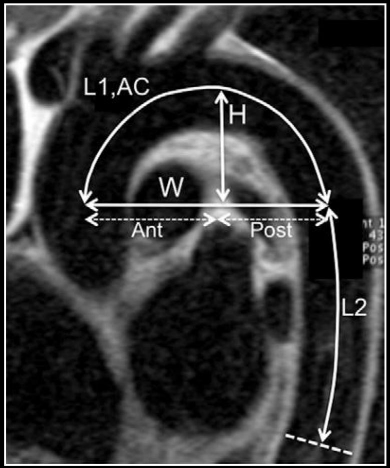
The Aorta Case: Motivation

Segmentation of the aorta is useful for:

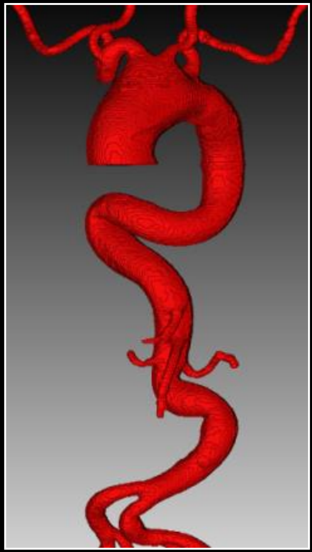
- Diagnosis and follow-up, based on several measurements like areas or diameters
- Preoperative planning
- Characterization for classification

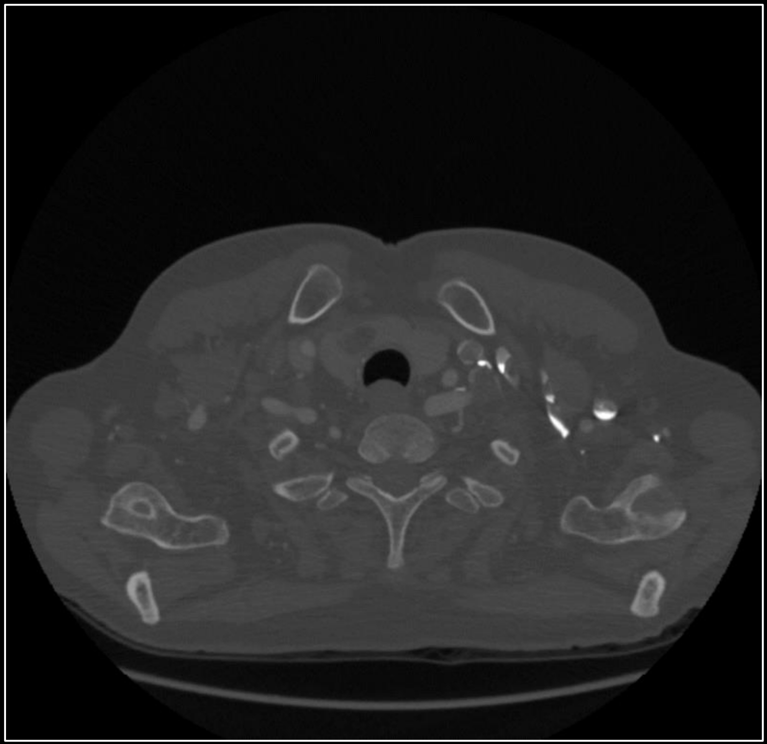
Segmentation should be automatic in order to

- Reducing time consuming and efforts made
- Achieve reproducibility



The Aorta Case





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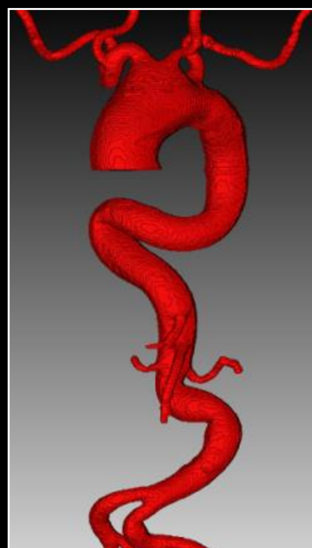
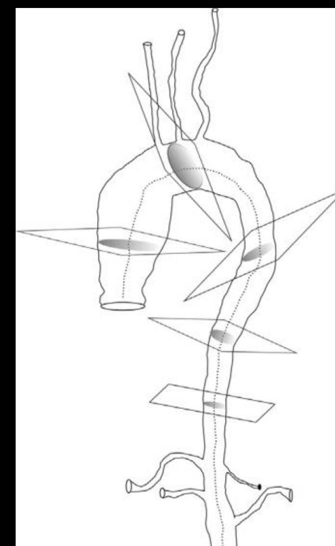
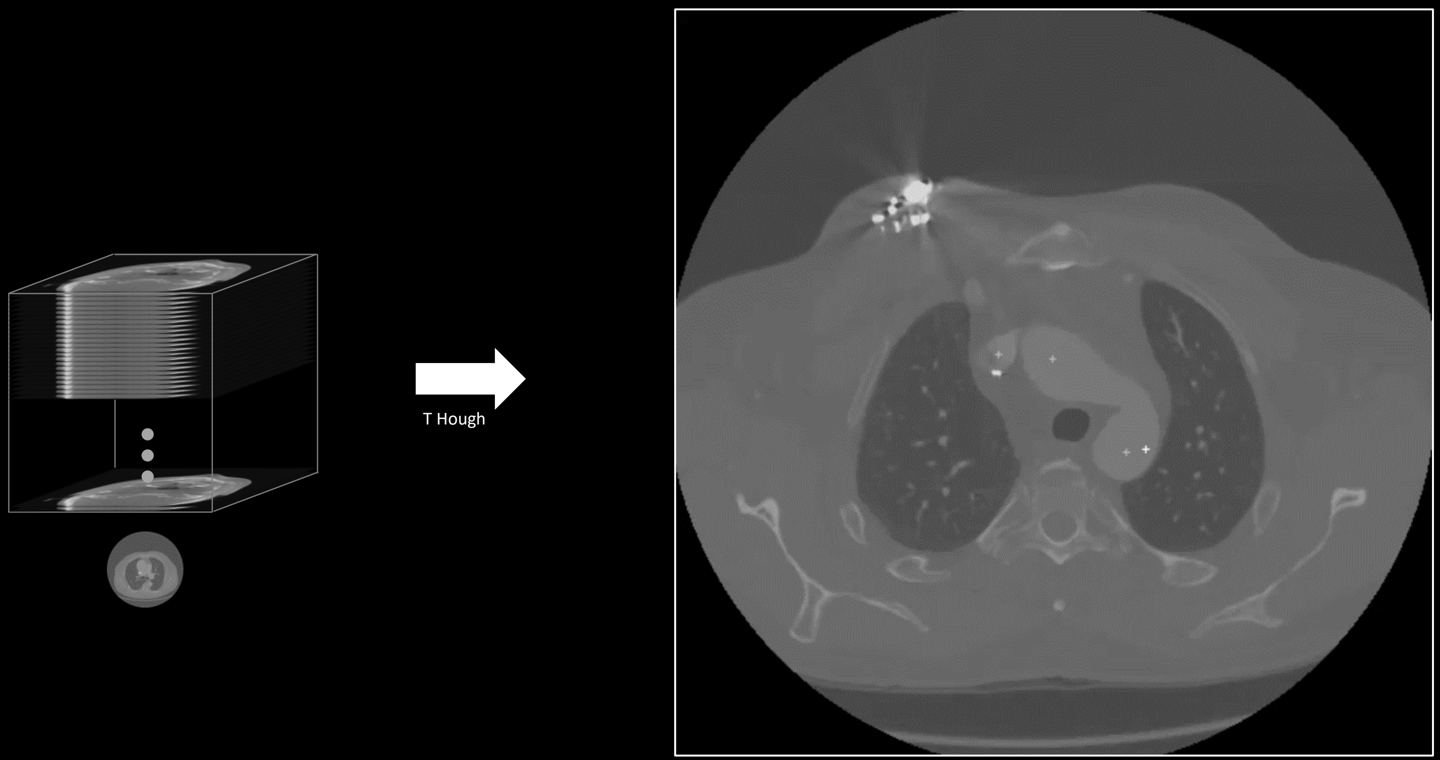




$$E_1(C, I, \sigma) = \frac{1}{|C|} \oint_C \nabla G_\sigma * I(C(s)) \cdot \bar{n}(s) ds$$

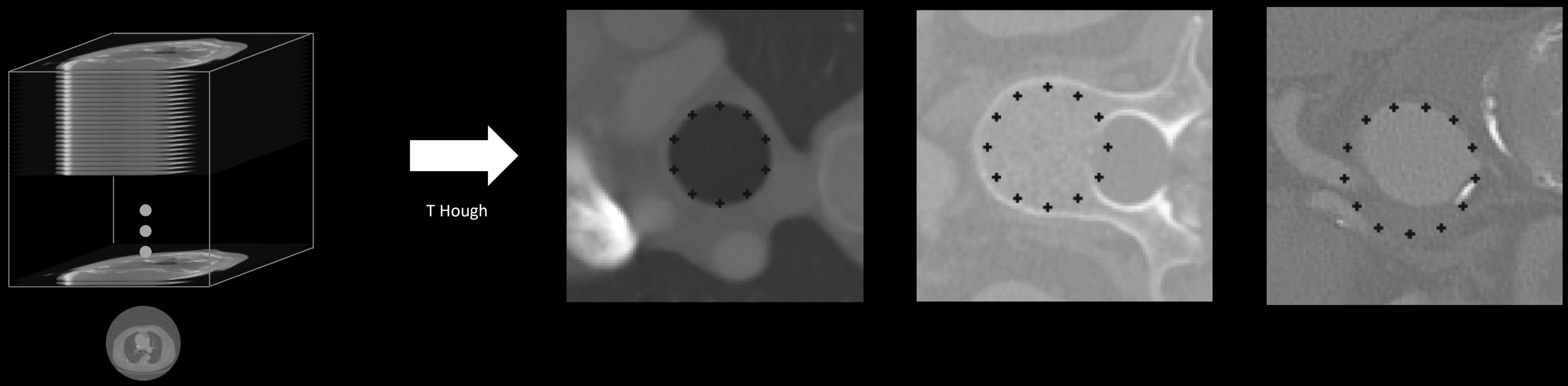
The Aorta Case. Methods.

First contour selection



The Aorta Case. Methods.

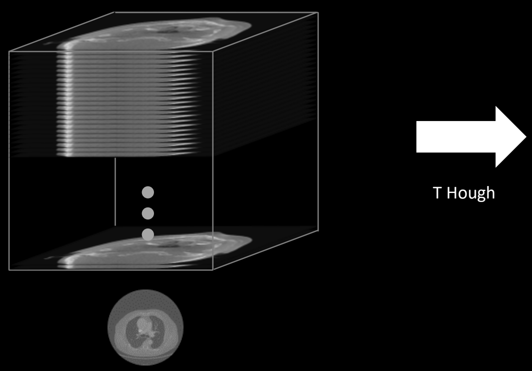
First contour selection

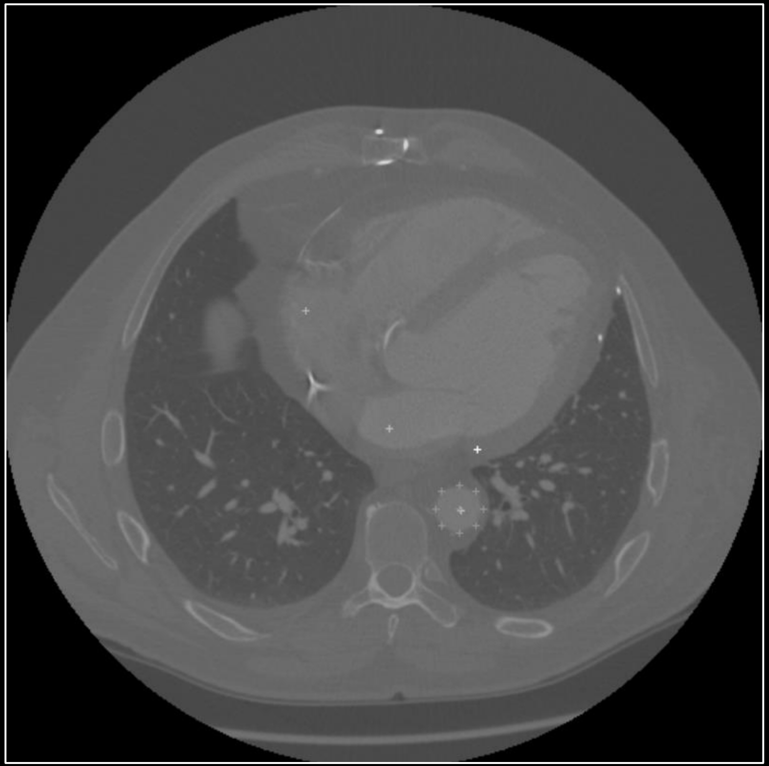


$$Q^z = \frac{V^z}{median\{V^z\}} - \frac{E^z}{median\{E^z\}} - \frac{\sigma^z}{median\{\sigma^z\}} - \frac{D^z}{median\{D^z\}}$$

The Aorta Case. Methods.

First contour selection





$$I(x,y,z)=\begin{cases} I(x,y,z) & \text{if} \quad I(x,y,z)\in[T_1,T_2] \\ T_1 & \text{if} \quad I(x,y,z)<T_1 \\ T_2 & \text{if} \quad I(x,y,z)>T_2 \end{cases}$$

The Aorta Case. Methods.

$$E(\alpha,\beta,c) = w_1 E_1\left(C_{c,\sigma}^{\alpha,\beta}\right) + w_2\sqrt{Area\left(C_{c,\sigma}^{\alpha,\beta}\right)} + w_3 Eccentricity\left(C_{c,\sigma}^{\alpha,\beta}\right)$$

$$E_1(C,I,\sigma) = \frac{1}{|C|}\oint_C \nabla G_\sigma * I(C(s)) \cdot \overline{n}(s)\,ds$$

$$C_{c,\sigma}^{\alpha,\beta} = \min E_1(C, I_c^{\alpha,\beta}, \sigma)$$

$$I_c^{\alpha,\beta}(x,y) = I\left(\begin{pmatrix} c_x \\ c_y \\ c_z \end{pmatrix} + \begin{pmatrix} \vdots & \cos\alpha & 0 & \sin\alpha \\ -\sin\alpha\sin\beta & \cos\beta & \cos\alpha\sin\beta & \\ -\cos\beta\sin\alpha & -\sin\beta & & \end{pmatrix}\begin{pmatrix} x \\ y \\ z \end{pmatrix}\right)$$

$$u = (\sin\alpha, \cos\alpha\sin\beta, \cos\alpha\cos\beta)$$

The Aorta Case. Methods.

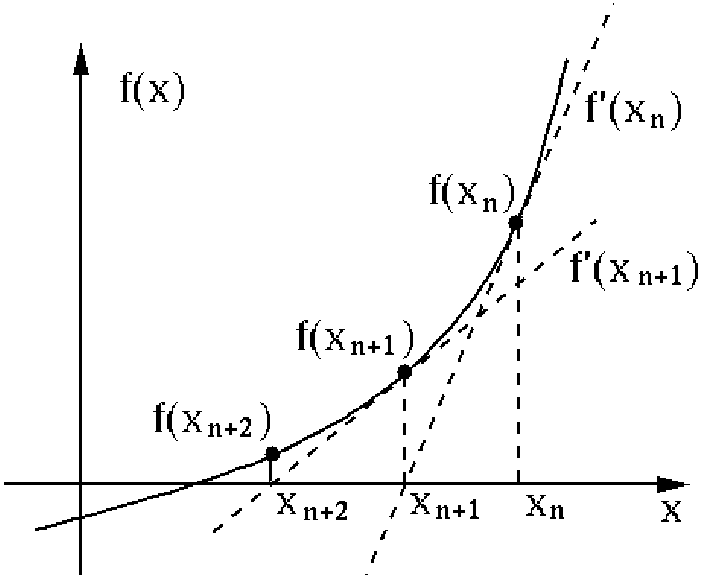
$$E(\alpha,\beta,c) = w_1 E_1\left(C_{c,\sigma}^{\alpha,\beta}\right) + w_2\sqrt{Area\left(C_{c,\sigma}^{\alpha,\beta}\right)} + w_3 Eccentricity\left(C_{c,\sigma}^{\alpha,\beta}\right)$$

Descendent Gradient

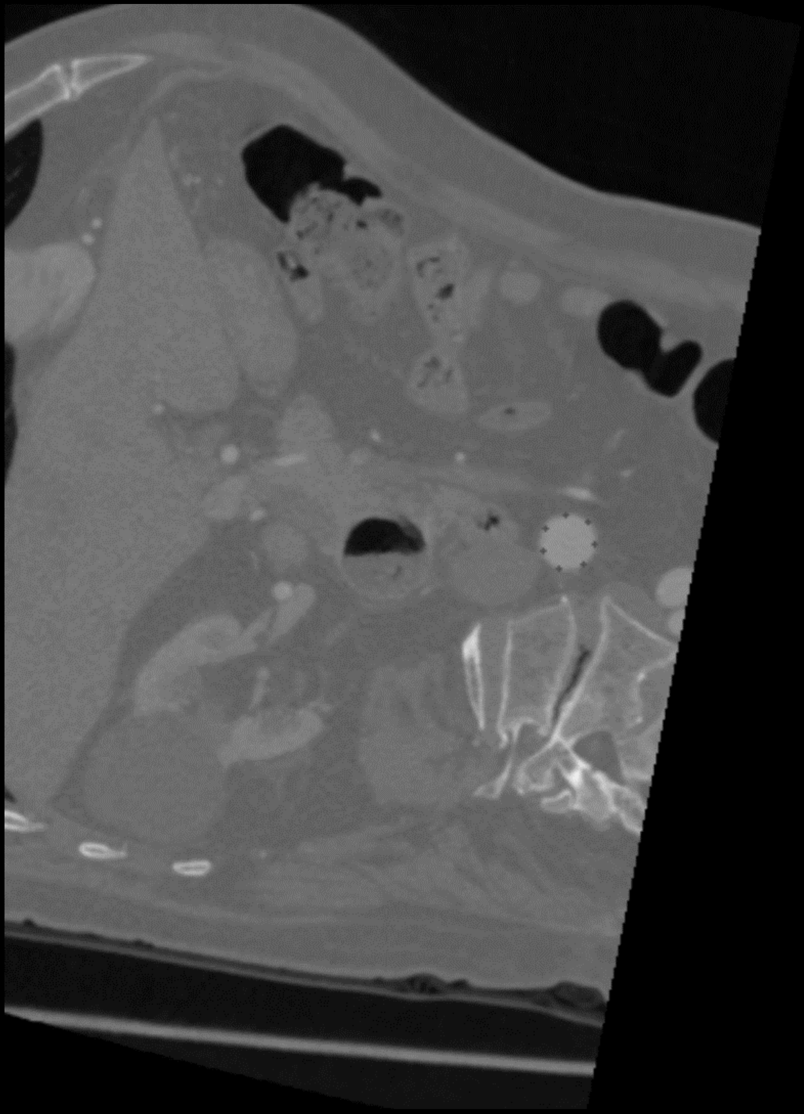
$$x_{n+1} = x_n - \lambda \cdot f'(x_n)$$

Newton-Raphson + Damping Parameter

$$x_{n+1} = x_n - \frac{f(x_n)}{f'(x_n) + \lambda}$$



The Aorta Case. Results.



The Aorta Case. Results.

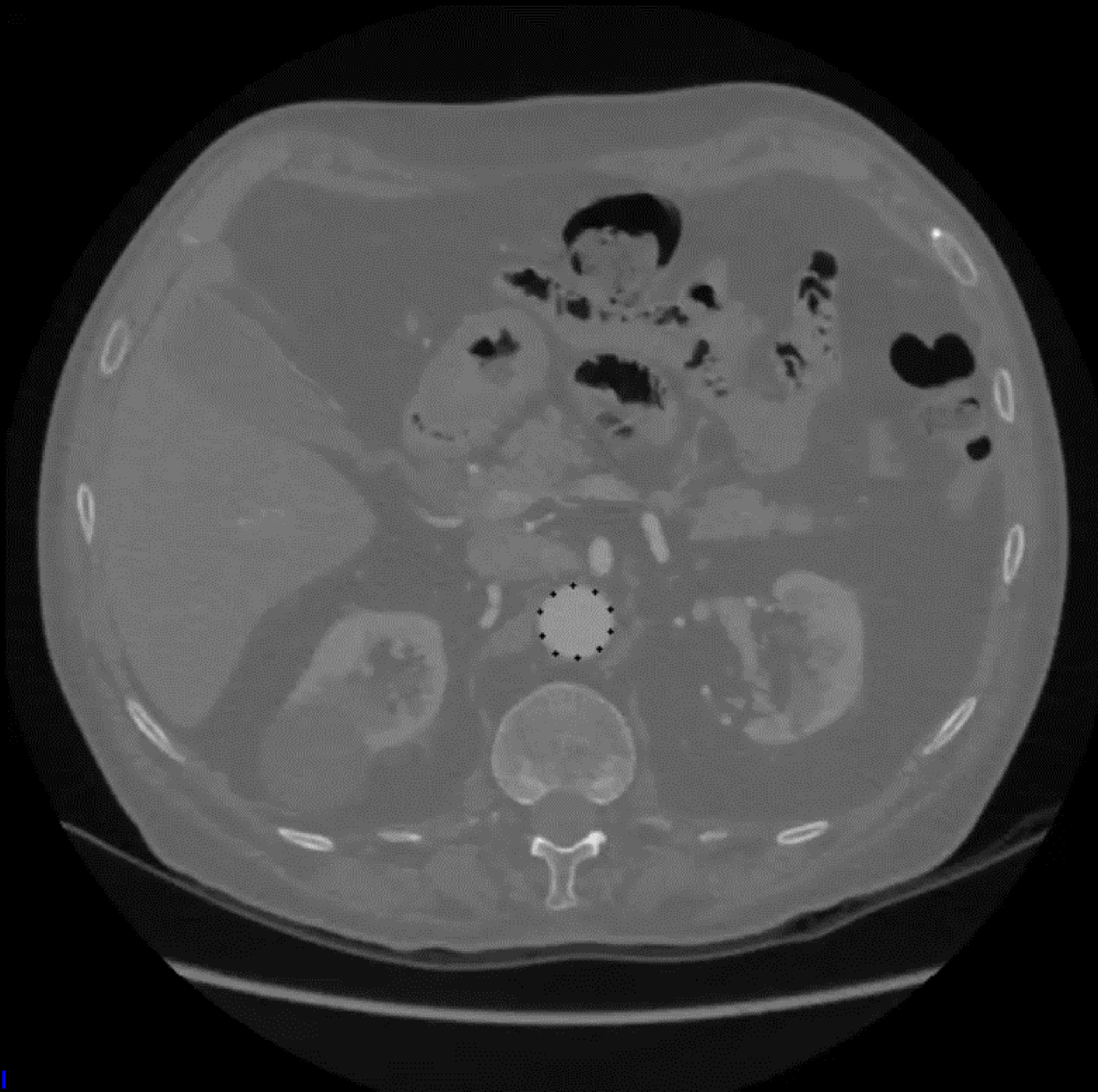
The Aorta Case. Results.

We have applied the former method to 2 DB's:

- CDB → Normal and adnormal cases with enhanced contrast
  - 116 Cases → 41,182 images
- LDIC → Normal cases with/without enhanced contrast.
  - 290 Cases → 54,125 images

DB	N Slices	Age	mA	Exp T	PS	ST	Kernel	Man
CDB	355 [35, 957]	65 [24, 89]	354 [147, 700]	505 [227, 600]	0.80 [0.49, 0.98]	1.380 [0.625, 5.0]	Standard Soft B31s	GE, SIEMENS
LDIC	189 [100, 766]	61 [14, 85]	309 [50, 581]	753 [400, 1160]	0.80 [0.49, 0.98]	1.380 [0.600, 5.0]	Standard Lung B30f, B45f, FC01	GE, SIEMENS, Toshiba, Philips

The Aorta Case. Results.



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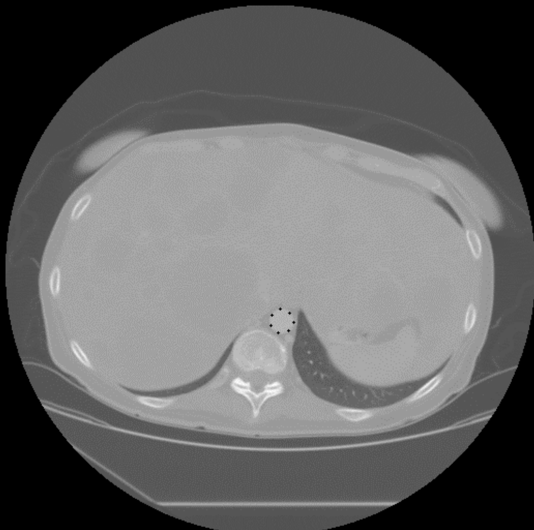
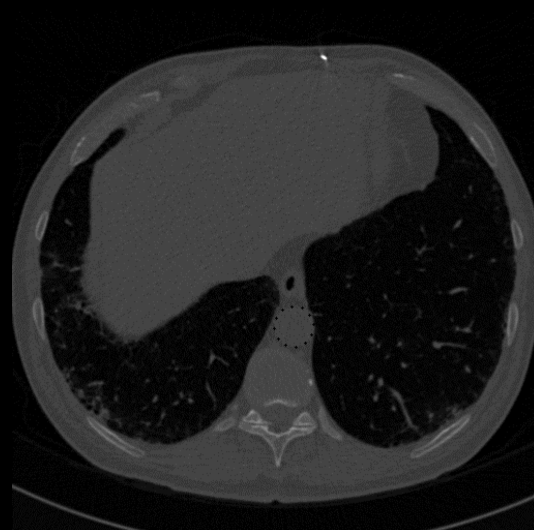
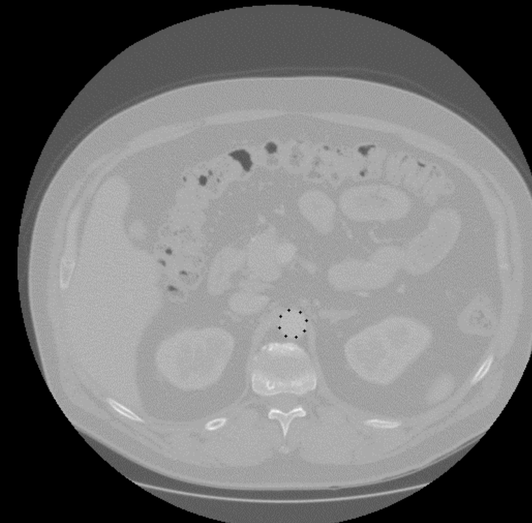

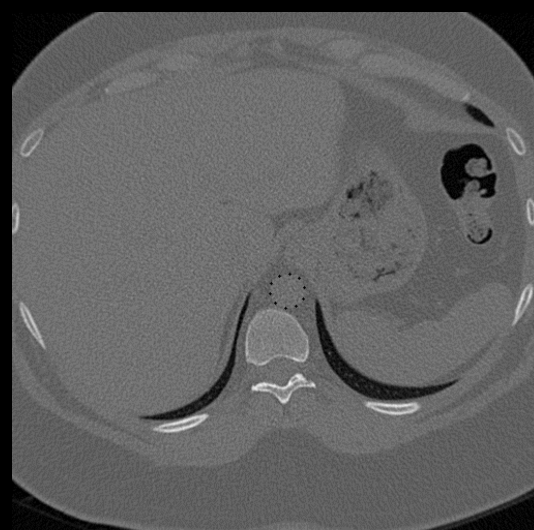


The Aorta Case. Results.

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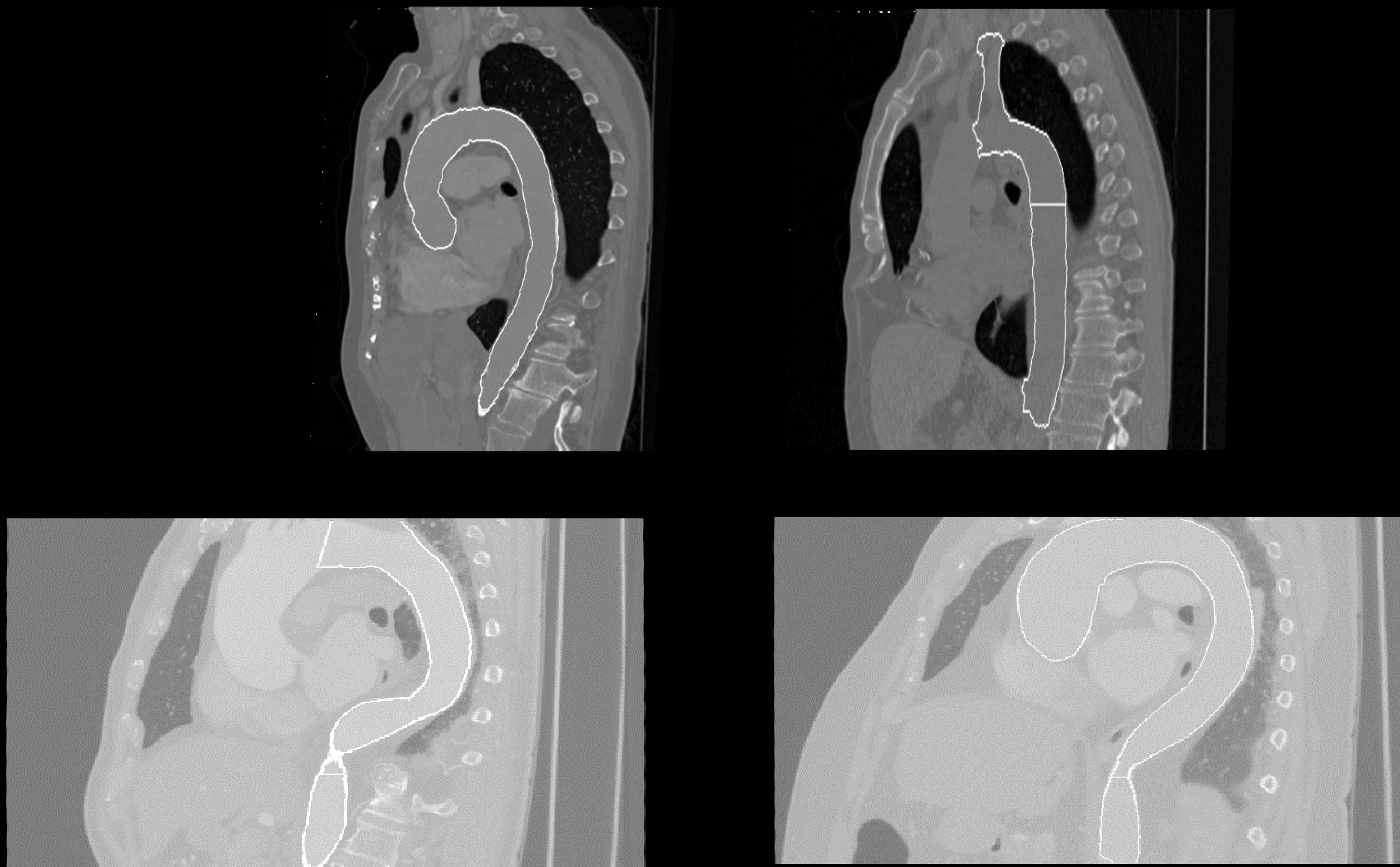

Conclusions.

We have developed a fast tracking algorithm especially designed for tubular structures.

The data bases used to verify the performance of the algorithm come from different CTs and various acquisition protocols were employed. The algorithm works well for more than 95% of cases.

We are currently analysing how well performs the algorithm compared with human manual tracing. Preliminary results are encouraging.