# A Semi-Automatic Methodology for Segmentation of the Coronary Artery Tree from Angiography


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# Summary

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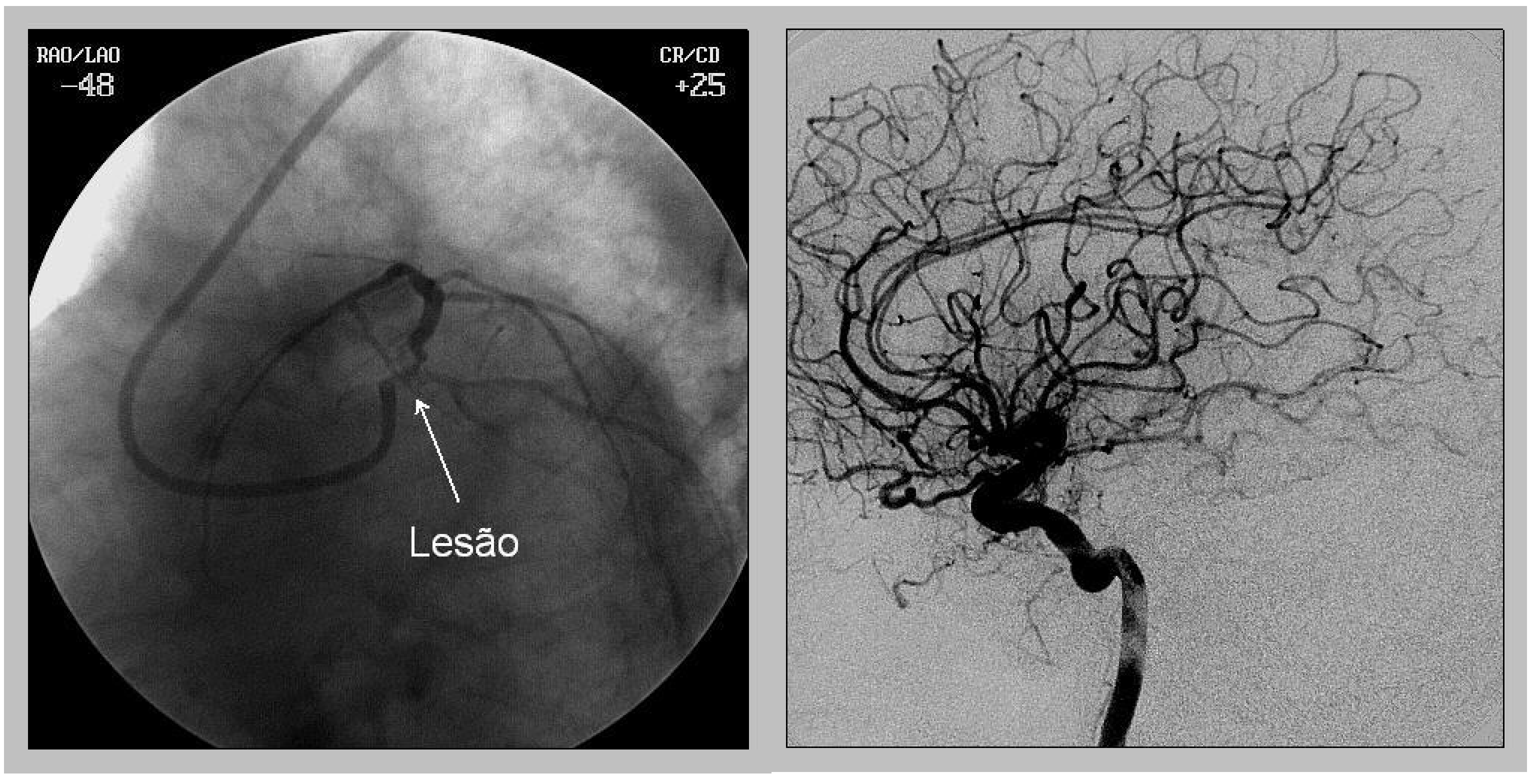
# Introduction

- Medical diagnostics using images has a considerable importance in many areas of medicine



# Definitions

- Coronary arteries are the set of arteries that deliver blood to the heart muscle
- Angiographies are images acquired from an X-Ray apparatus for vessels analysis
- Coronary artery disease (CAD) can be identified from angiography analysis
- Stenosis is the narrowing in any artery

# Motivation

- Statistics show that vessels diseases are one of the biggest reasons for mortality in the world

- Between 3.6% and 6% of the world population is suffering of any kind of aneurism and/or stenosis

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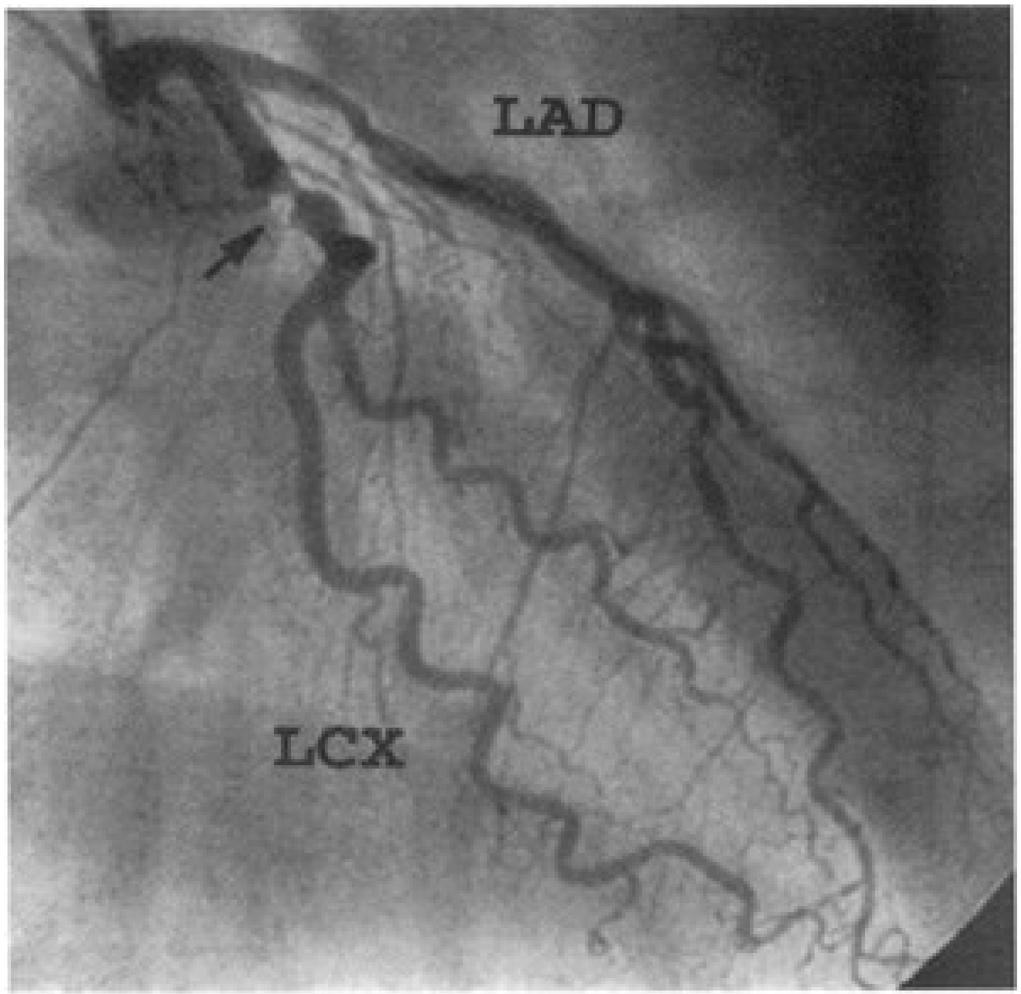
# Motivation

- Stenosis example.



# Motivation

- Traditional methods for stenosis analysis are based on the doctor’s personal experience and visual evaluation

- A computational approach for stenosis analysis has many advantages

- An important step for the stenosis analysis is the blood vessels detection

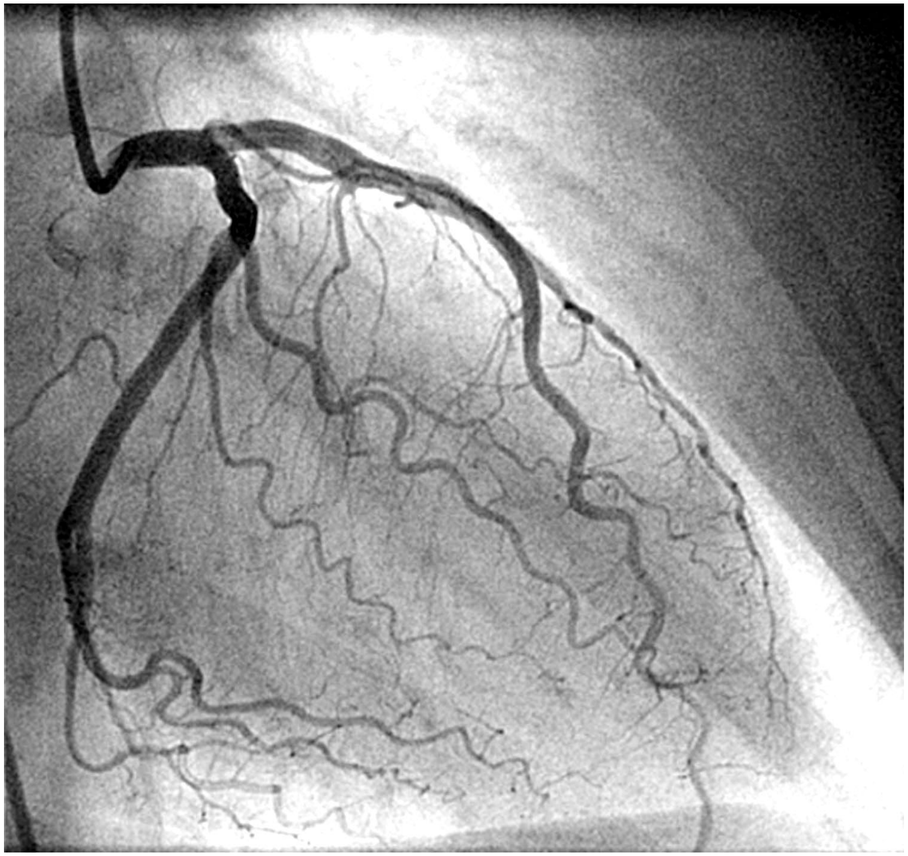
# Problem Statement

- Given a digital angiography from an X-Ray CathLab apparatus, the problem is to extract the cardiac coronary tree with the maximum branches as possible

- Challenges on this approach:
  - Complex nature of vessels tree
  - Imperfection on the images (noise)
  - Brightness and contrast non-uniforms

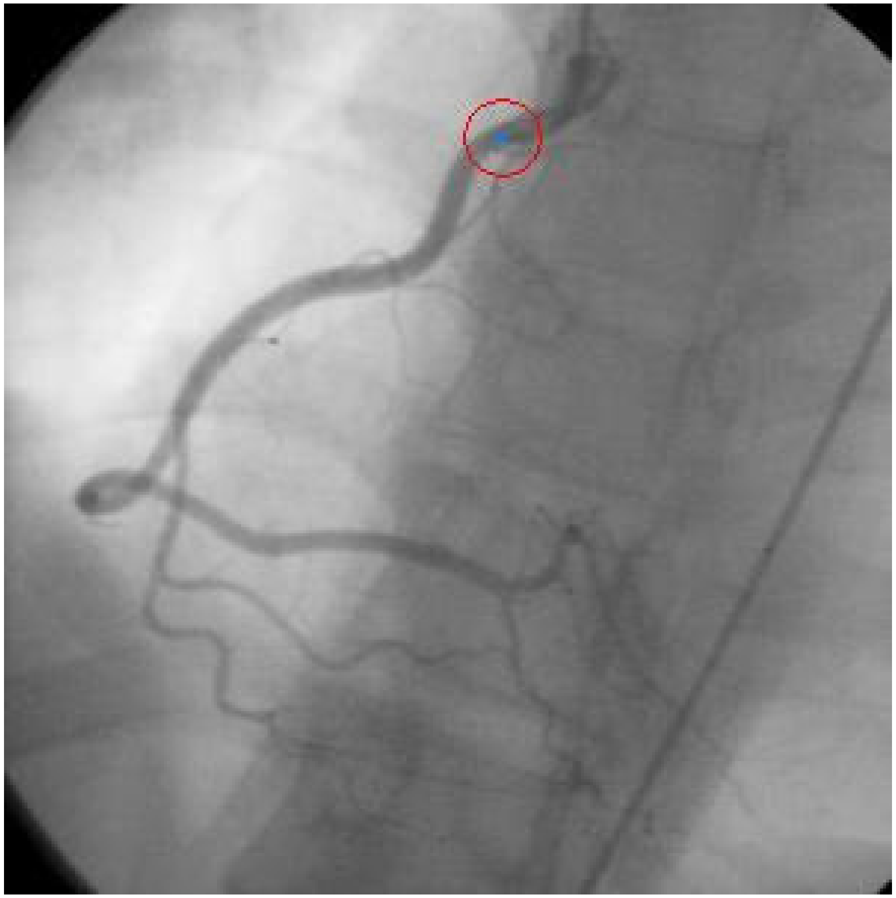
# Objective

- To develop an approach for a Semi-Automatic Segmentation of the cardiac coronary artery tree  from angiographies



# Methodology

- The artery identification is based on a threshold applied to ROI around a seed point. This seed point is given by the doctor with a mouse click



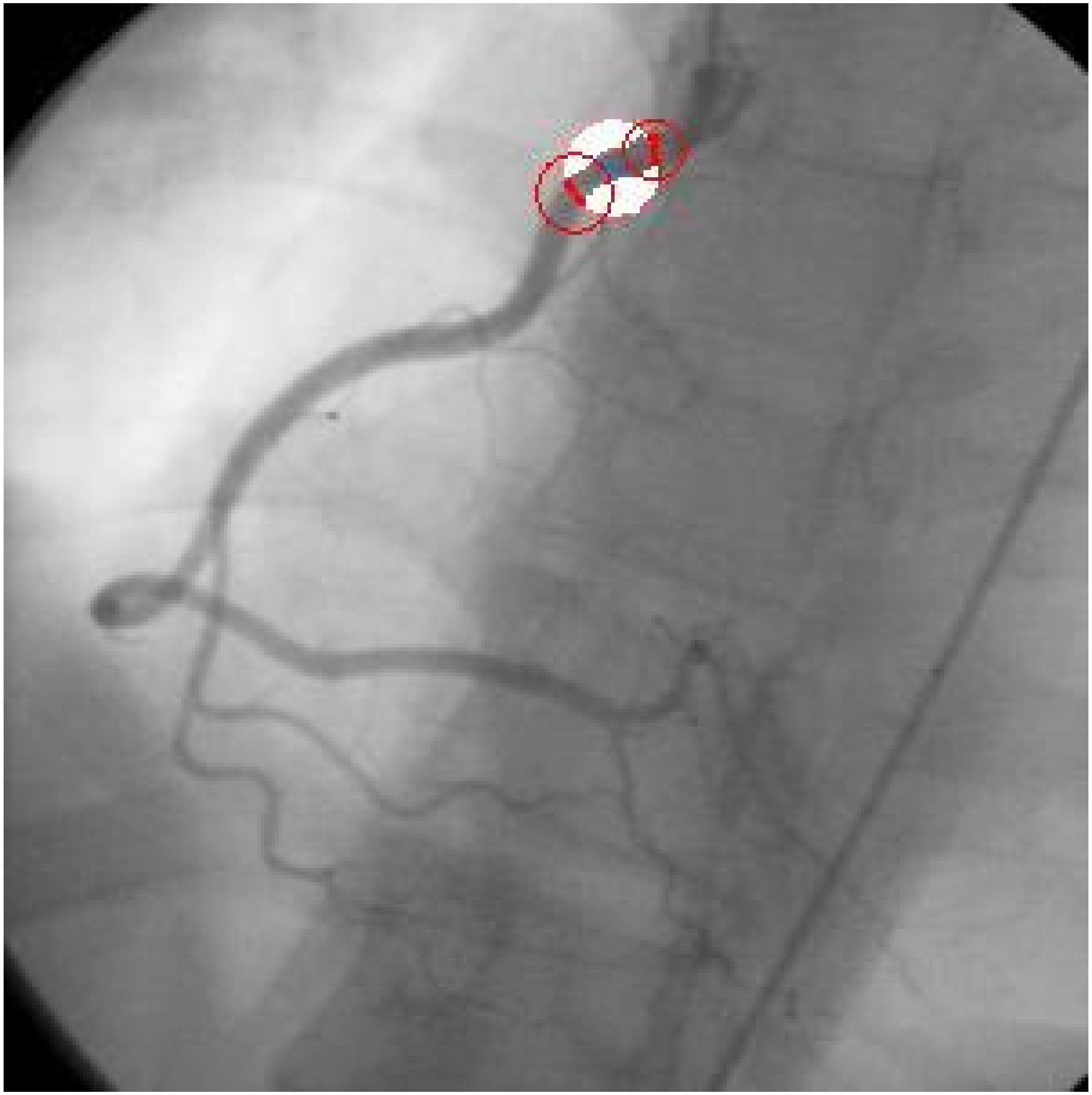
# Methodology

- In the circle area, all the pixels intensities are evaluated to find a good local threshold to identify which ones belong to the coronary

- After that, it is possible to compute the artery diameter

- In both artery identified ends, the diameter is computed and its mean point is the center of new circles

# Methodology



# Methodology

- The process continues until the circle radius is smaller than a minimum specified
- Connected components is used to avoid non-vessel points being seen as vessels points

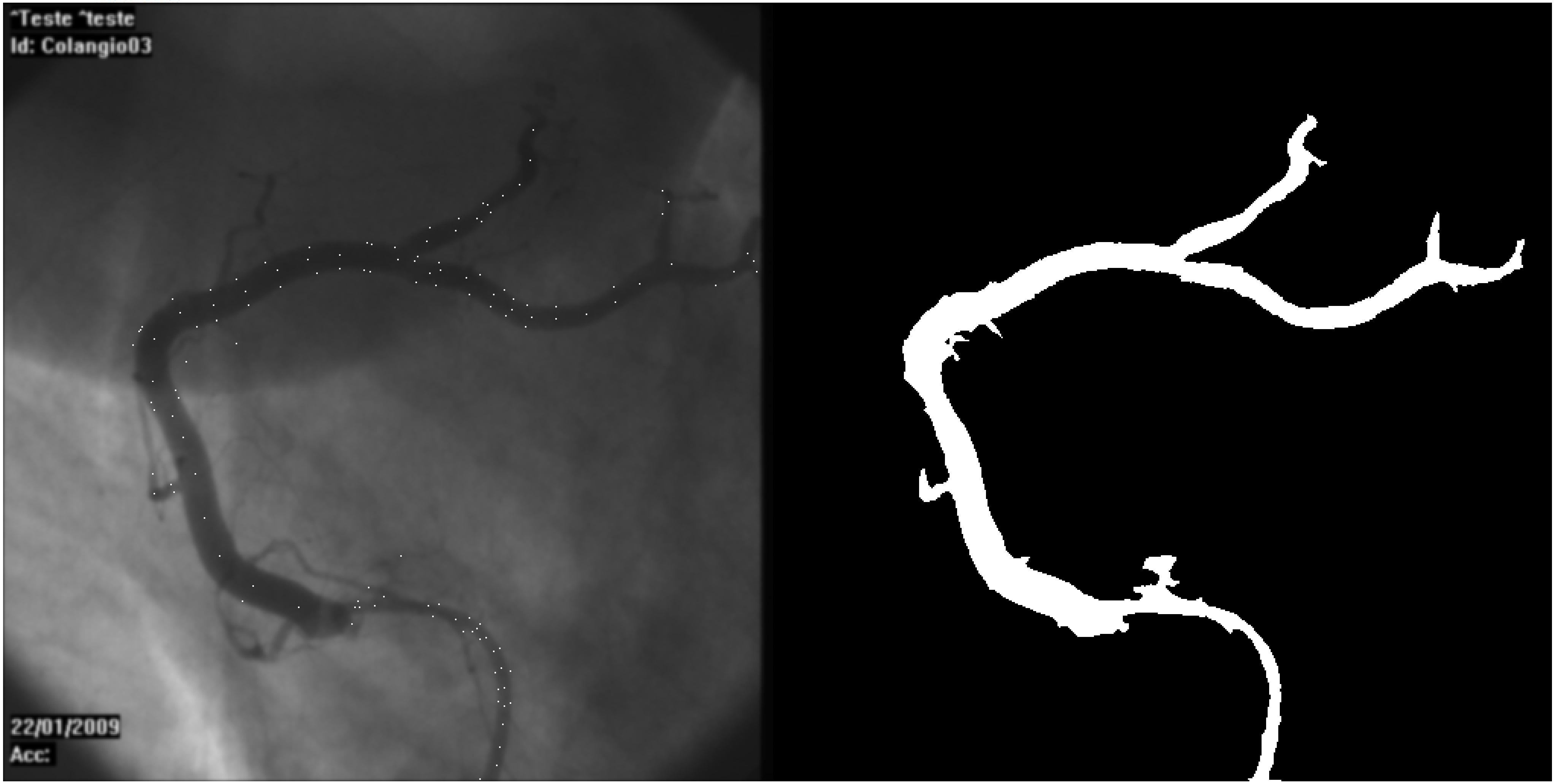
# Challenges

- Circle radius – Depends on the image resolution, artery diameter, algorithm for thresholding, image quality

- Algorithms for thresholding (Niblack, otsu, sauvola, etc)

- Images with different brightness and contrast depending on the patient weight

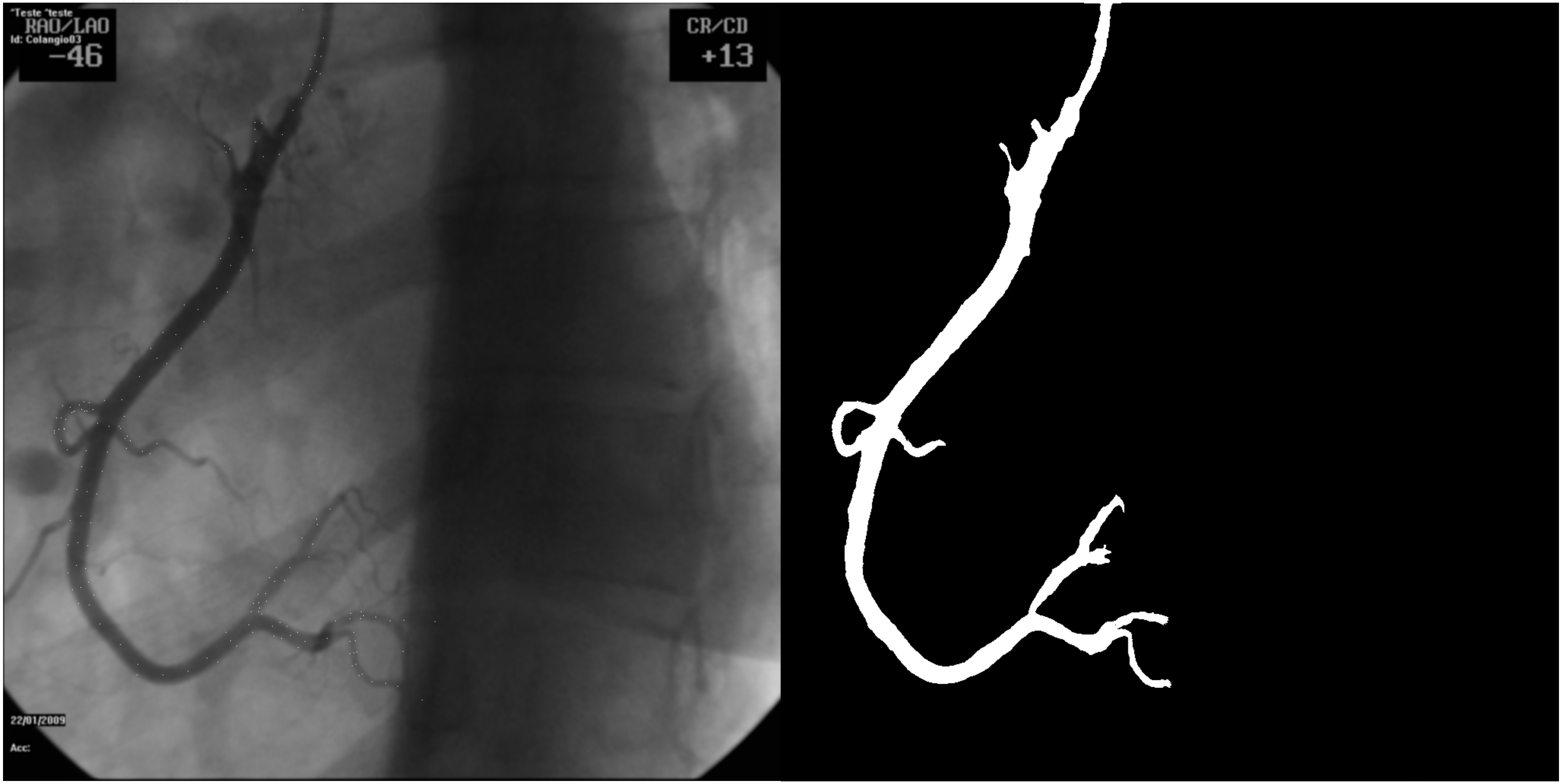
# Some Results




$$Niblack\ and\ 0.01\ of\ std.$$

$$Radius = Diameter$$

# Some Results




$Niblack\ and\ 0.01\ of\ std.$

$Radius = Diameter$

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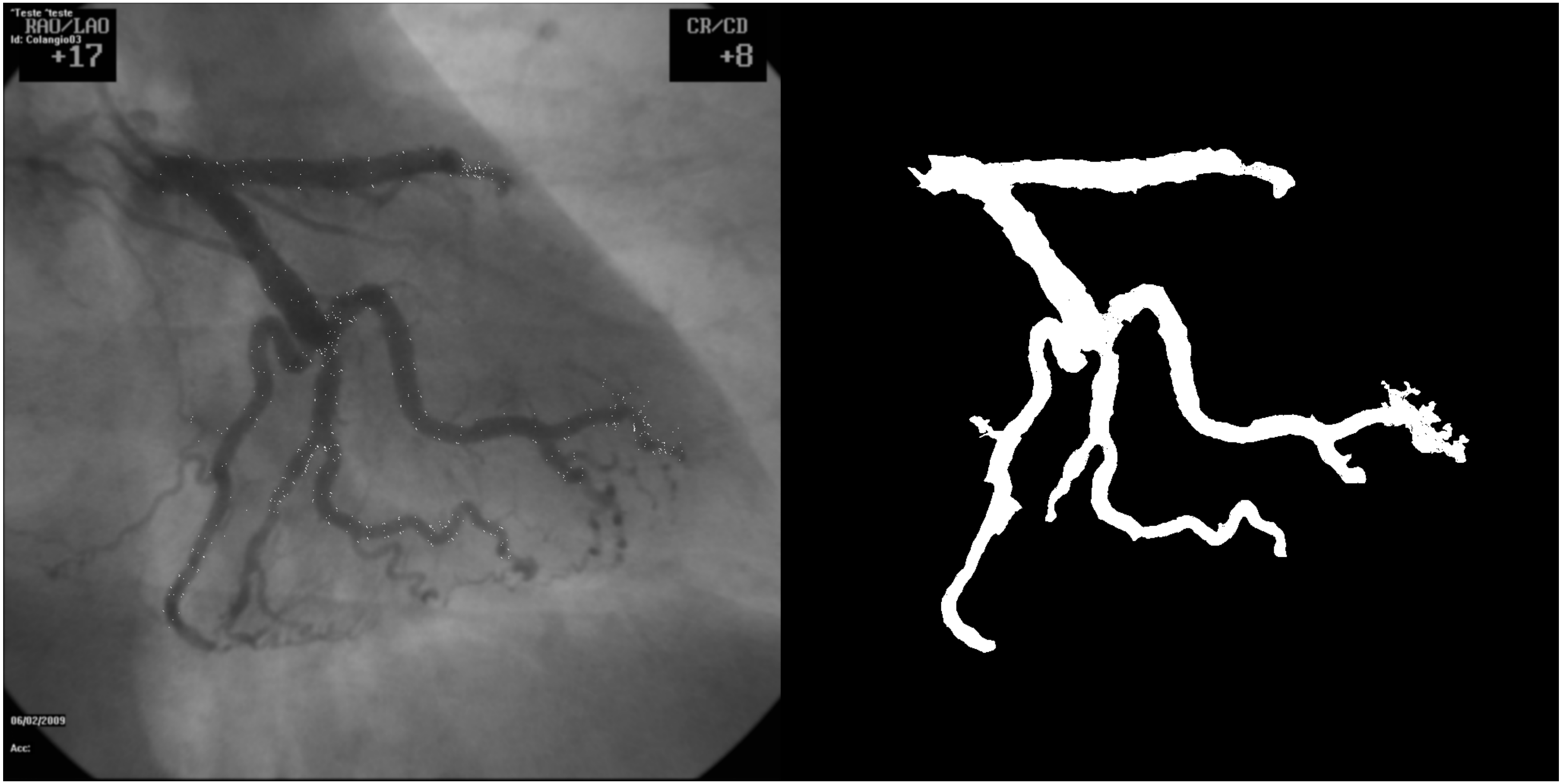
# Some Results




$$Niblack\ and\ 0.01 of\ std.$$

$$Radius = Diameter$$

# Some Results

Demo Movie

# Vessel Resemblance Function – Schrijver and Slump

- This approach gives a vessel resemblance value for each pixel in the image
- It works with feature image
- It works with different scales

# Hessian Matrix H

$$G = \{(u, v, z) \mid z = g(u, v)\}$$

$$H(x) = \begin{bmatrix} g_{uu}(x) & g_{uv}(x) \\ g_{vu}(x) & g_{vv}(x) \end{bmatrix}$$

$$g_{ab}(x;\sigma) = \sigma^2 h_{ab}(x;\sigma) * g(x)$$

# Eigenvalues of Hessian

- Strongest Eigenvalue gives the strength of the 3D surface

- The artery is a dark region against a brighter background – First derivative increases which means a positive value for the first eigenvalue

- All we need is to sort  these eigenvalues and get the strongest positive ones as possible artery points.

$$|\lambda_1| \geq |\lambda_2|$$

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# Resemblance function

$$V(x;\sigma) = \begin{cases} 0 & if \quad \lambda_1 < 0, \\ \exp(-\frac{{R_B}^2}{2{\beta_1}^2})\left[1 - \exp(-\frac{S^2}{2\beta_2^2})\right], & otherwise \end{cases}$$

$$R_B = \frac{|\lambda_2|}{|\lambda_1|} \qquad S = \sqrt{\lambda_1^2 + \lambda_2^2}$$

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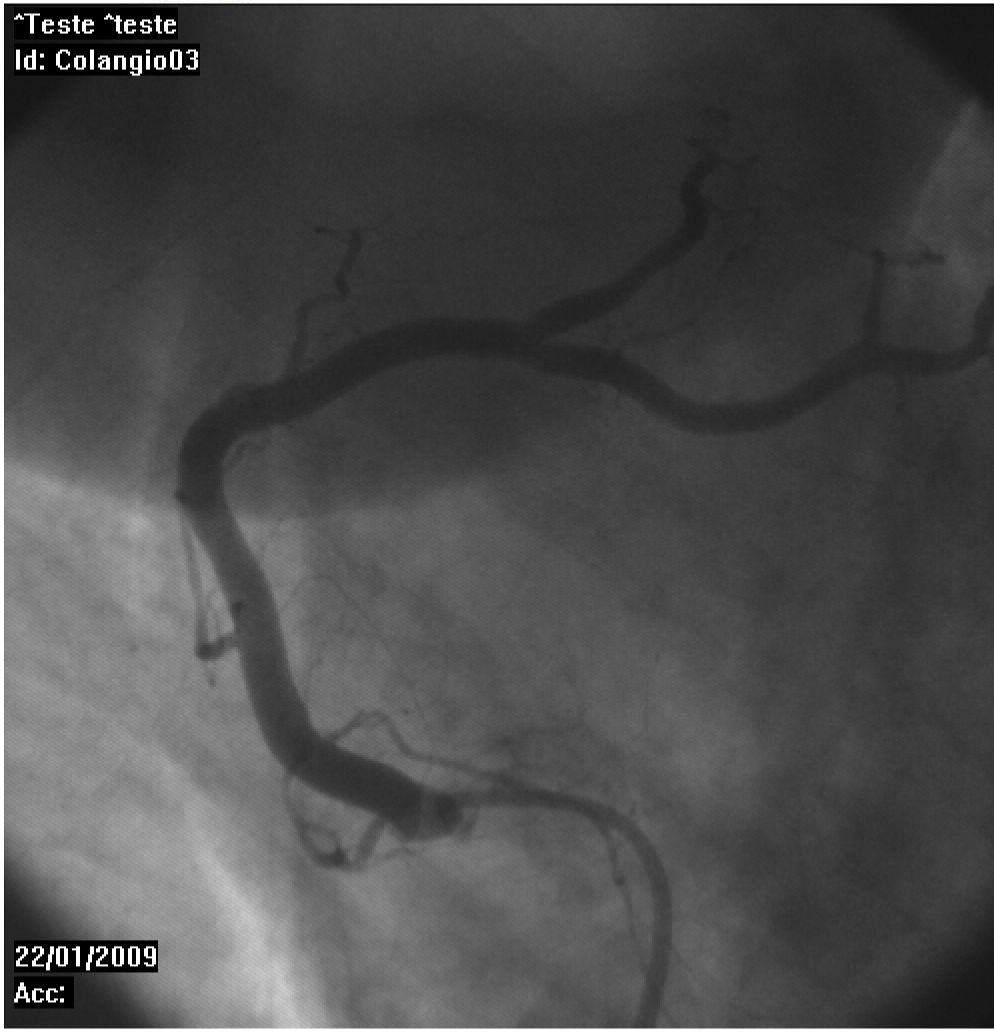
# Result





$$\beta_1 = 1.0, \beta_2 = 8.0 \, and \, \sigma \, between \, 2 \, and \, 4$$

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# Next Steps

- To combine these approaches as a possible solution to avoid branch missing.

- Which global method to use?
  - Scaling Variations?
  - Mathematical Morphology?
  - Differential Geometry?

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# Some References

Lacoste, C. , Finet G. and Magnin, I. E. Coronary tree extraction from X-ray angiograms using marked point processes. In *IEEE International Symposium on Biomedical Imaging (ISBI)( 2006), pp. 157-160.*

*Quek, F. and Kirbas, C. A Review of Vessel Extraction Techniques and Algorithms. ACM Computing Surveys (2004), vol. 36, 2, pp. 81–121.*

*Schrijver M, Slump C H. Automatic segmentation of the coronary artery tree in angiographic projections. In: Proceedings of ProRISC 2002. Veldhoven, 2002. 449–464*

*Sun, Y. Automated identification of vessel contours in coronay arteriograms by an adaptive tracking algorithm. IEEE Transactions on Medical Imaging (1989), vol. 8,1, pp.  78–88.*

*Zhou S., Yang J., Chen W. and Wang Y. New approach to the automatic Segmentation of coronary artery in X-ray angiograms. Sci China Ser F-Inf Sci (2008), vol. 51,1, pp. 25-39.*

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15 anos npdi 1990-2005

# Questions

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