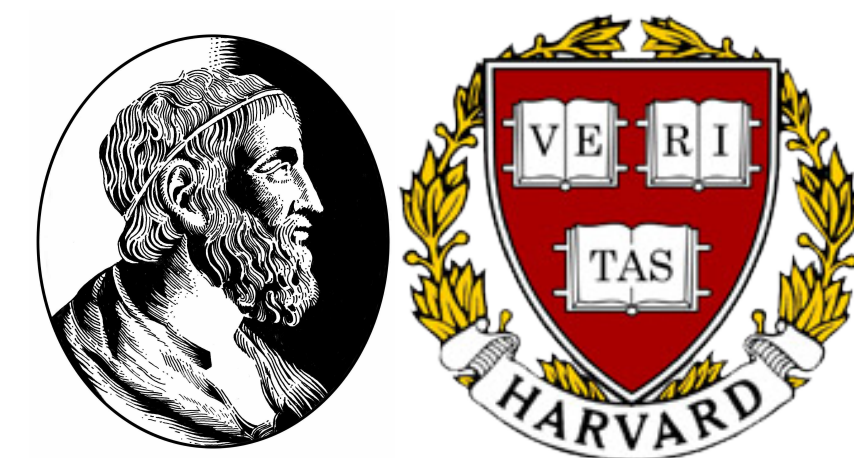


Vessel Cross-section Tracking in CTA and MRA Images Using Hough Transform



Maysa M. Garcia de Macedo, Choukri Mekkaoui (Harvard Medical School), Marcel Parolin Jackowski

Institute of Mathematics and Statistics - Department of Computer Science
University of São Paulo, Brazil
maysa@ime.usp.br

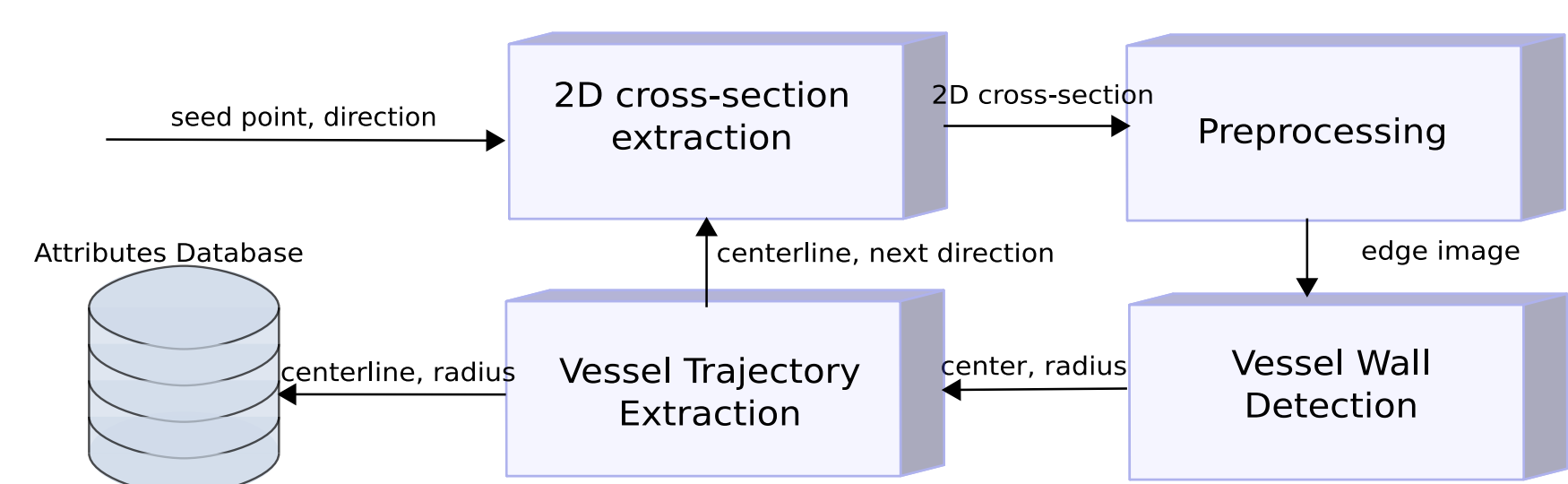
IV Workshop CINAPCE, August 12-14, 2010, São Carlos, Brazil

Introduction

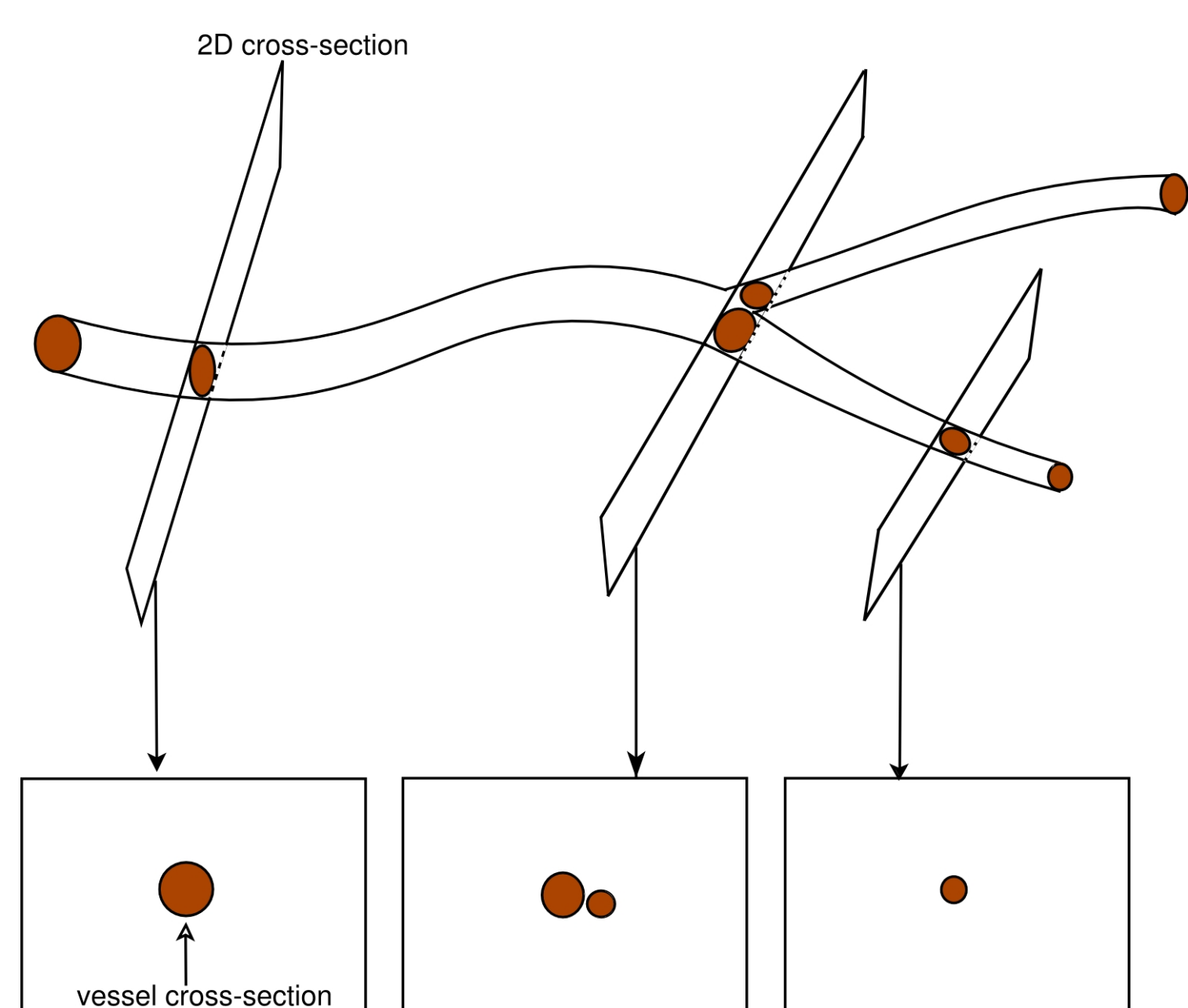
In the proposed approach, Hough transform (HT) is used for detecting vessel cross-sections as circles, so the diameters detected can be used as vessel diameters along the tracking. Unlike previous tracking approaches [2], our approach substitutes the multiscale scheme for the HT in order to detect vessel diameters.

Vessel Tracking Method

The goal of the proposed vessel tracking is to construct a vessel skeleton based on the extracted centerlines on several slices [3].



CTA and MRA images show vessels as high intensity profiles, with a maxima near their centers.



Initialization and Preprocessing

An extraction plane orthogonal to a given vessel is selected from a 3D image to start the tracking process. The preprocessing step consists in applying an Anisotropic diffusion filter, Morphological opening and subtraction operators and Canny filter.

Vessel Detection by Hough Transform

Once the edge image is obtained, the HT is computed to identify circle centers and their estimated diameters as scale.

Vessel Tangent Estimation

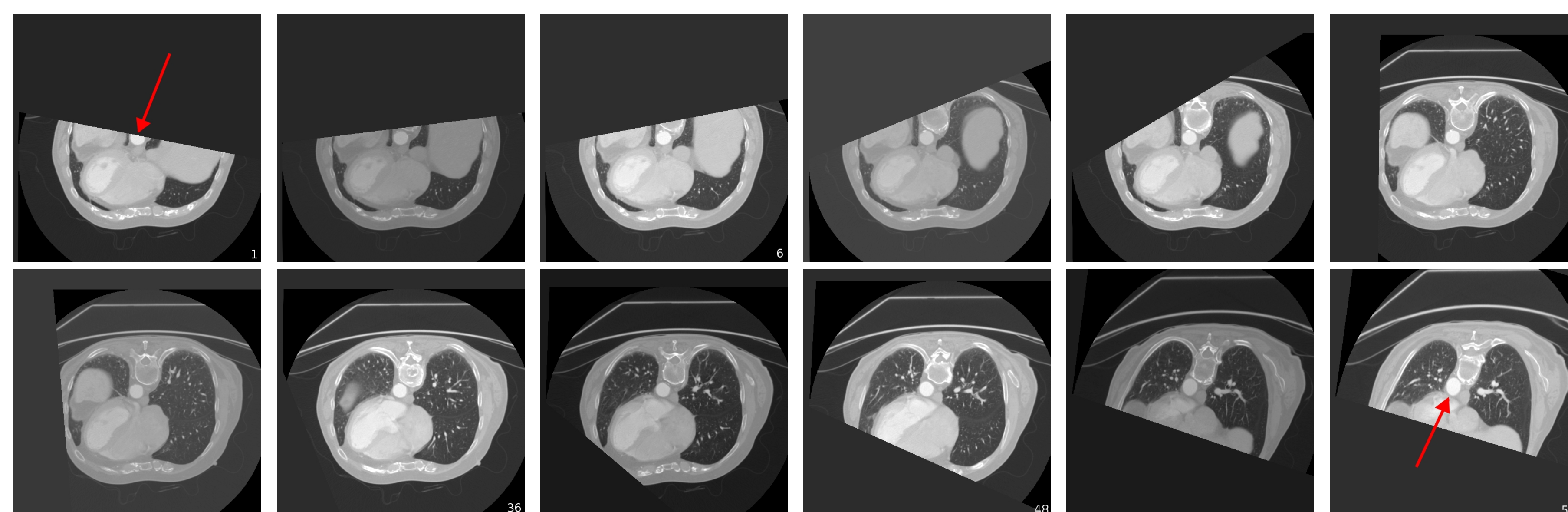
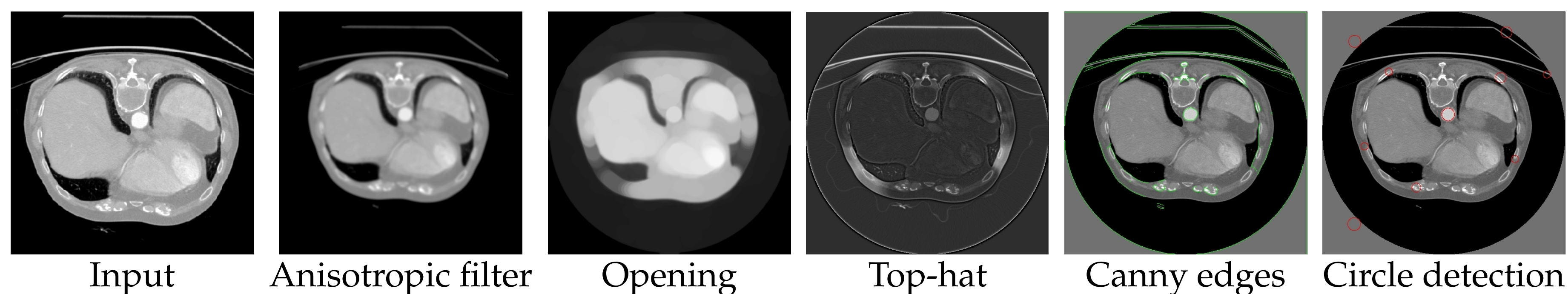
Based on this centerline and on the detected radius taken as a vessel scale, eigenvalues ($\lambda_1, \lambda_2, \lambda_3$) and eigenvectors ($\vec{e}_1, \vec{e}_2, \vec{e}_3$) are computed from a Hessian matrix computed at the centerline location. The eigenvector corresponding to the eigenvalue closer to 0 (λ_1) indicates the vessel direction (\vec{e}_1).

$$\vec{t}_i = \text{signal}(\vec{e}_1 \cdot \vec{t}_{i-1})\vec{e}_1 \quad (1)$$

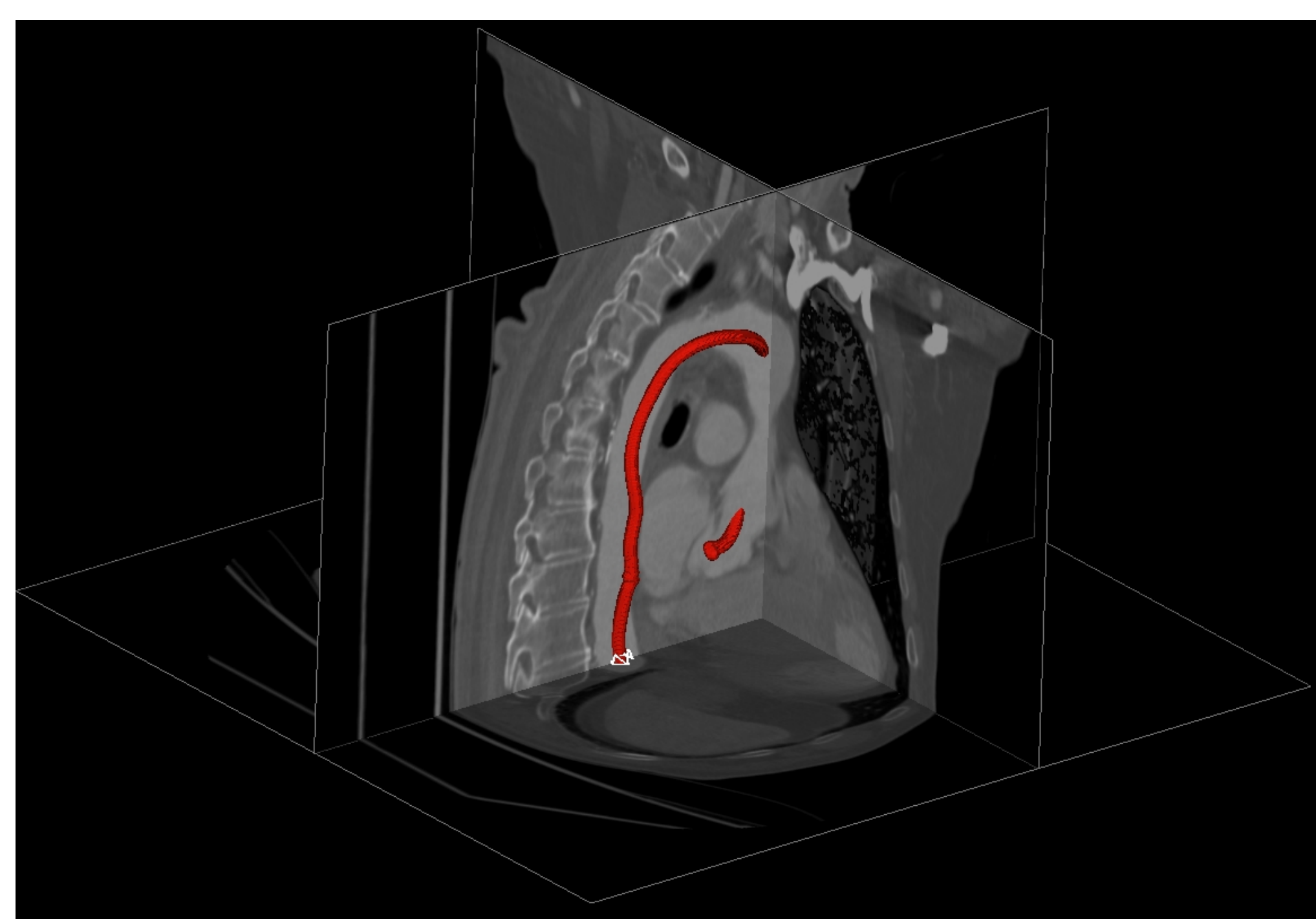
The direction \vec{t}_i defines the normal to the next extraction plane in the 3D image. According to Alyward [1] it is necessary recover from local discontinuities.

Results – Real Images

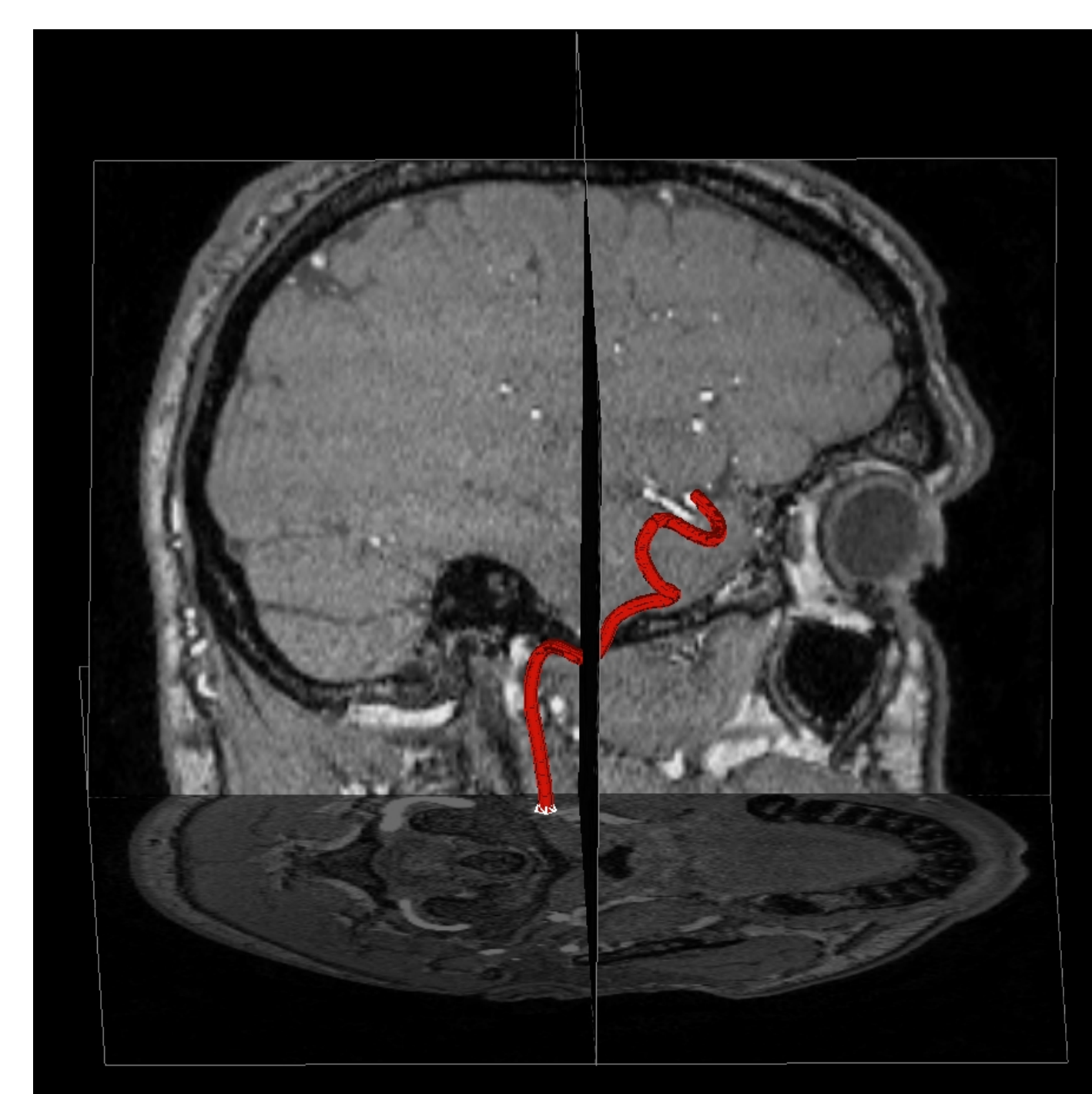
The methodology was implemented using C++ language and auxiliary libraries such as *Visualization Toolkit* and *Insight Toolkit*. Both synthetic images and a real CTA and MRA image was used in order to assess whether the centerlines and vessel tangent directions are correctly extracted.



Sequence of 2D cross-sections extracted during the tracking of the thoracic aorta

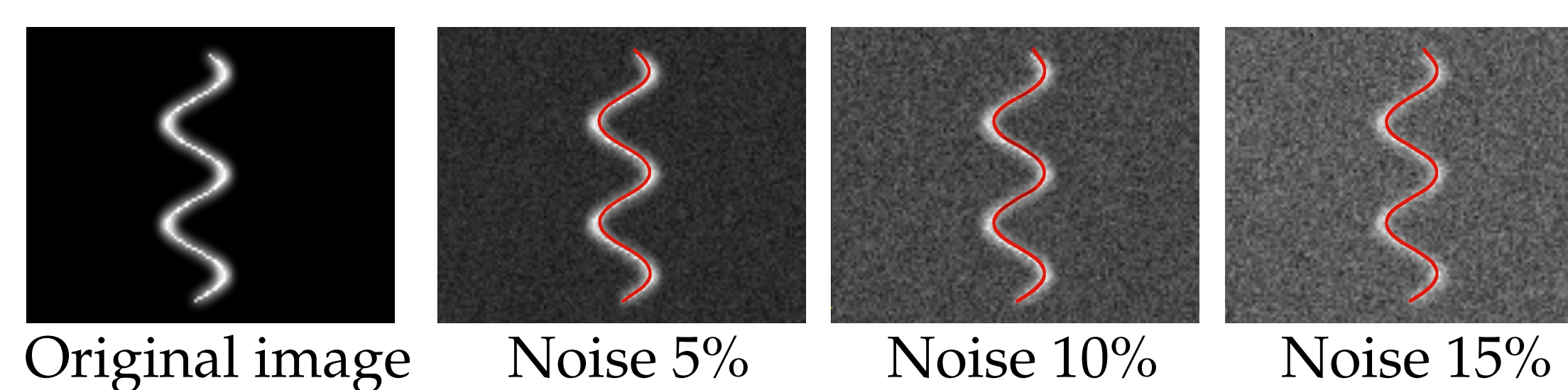


Thoracic aorta trajectory in CTA image



Carotid artery trajectory in MRA image

Results – Synthetic Images



Sinusoids used as synthetic data. From left to right, sinusoids 1 to 6.

For our set of sinusoids synthetic images, the average distance to the ground-truth centerlines, is 1.5 mm.

Discussion and Conclusions

In the present study, we have proposed a semi-automated method to detect and track vessel centerlines in CTA and MRA images. The methodology has shown to work well under significant amounts of noise. The main contribution of this work is the use of HT to define the seed point for tracking and detecting the vessel scale without resorting to multiscale analysis techniques. Future work will focus on treat the bifurcation problem.

References

- [1] S. Alyward, E. Bullitt. Initialization, Noise, Singularities, and Scale in Height Ridge Traversal for Tubular Object Centerline Extraction. In *IEEE Transaction on Medical Imaging*, 2002.
- [2] D. Lesage, E. D. Angelini, I. Bloch, G. Funka-Lea. A Review of 3D Vessel Lumen Segmentation Techniques: Models, Features and Extraction Scheme In *Medical Image Analysis*, 2009.
- [3] C. T. Metz, A. C. Weustink, N. R. Mollet, T. van Walsum, W. J. Niessen. Coronary Centerline Extraction from CT Coronary Angiography Images Using a Minimum Cost Path Approach In *Medical Physics*, 2009.