Vessel Centerline Tracking in CTA and MRA Images Using Hough Transform

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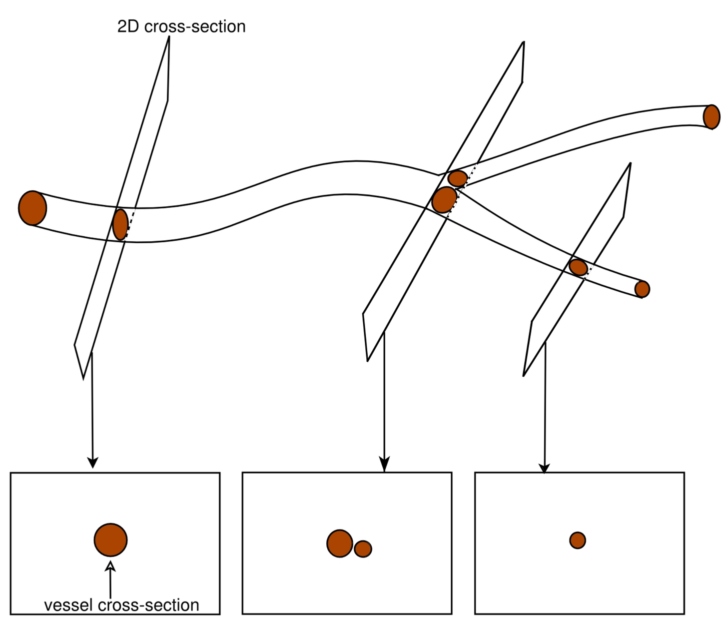
Main Goal

This work presents a new approach to automatically track vascular networks from CTA and MRA images based on the extracted centerlines. This method has as vantage the use of Hough transform (HT) to define the seed point for tracking and detecting the vessel scale without resorting to multiscale analysis techniques.

Vessel Tracking Method

The literature about vessel extraction is vaste [1], but unlike previous tracking approaches [2], this work proposes HT substituting the multiscale scheme in order to detect vessel diameters.
For each cross-section extracted we analize candidates of bifurcation point.



Scheme of orthogonal planes extraction.

Initialization and Preprocessing

An orthogonal plane extraction 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

The HT is computed to identify circle centers [3], and their estimated diameters as scale.

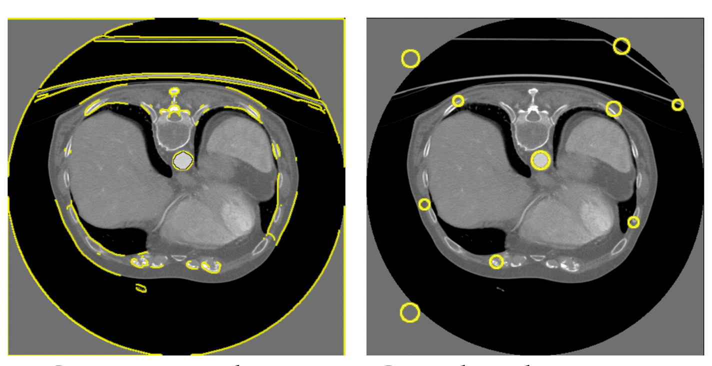
Vessel Tangent Estimation

Based on this centerline and on the detected radius taken as a vessel scale, eigenvalues (λ_1, λ_2, λ_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 ($\vec{e}_1$).

$$\vec{t_i} = signal(\vec{e}_1 \cdot \vec{t}_{i-1})\vec{e}_1 \qquad (1)$$

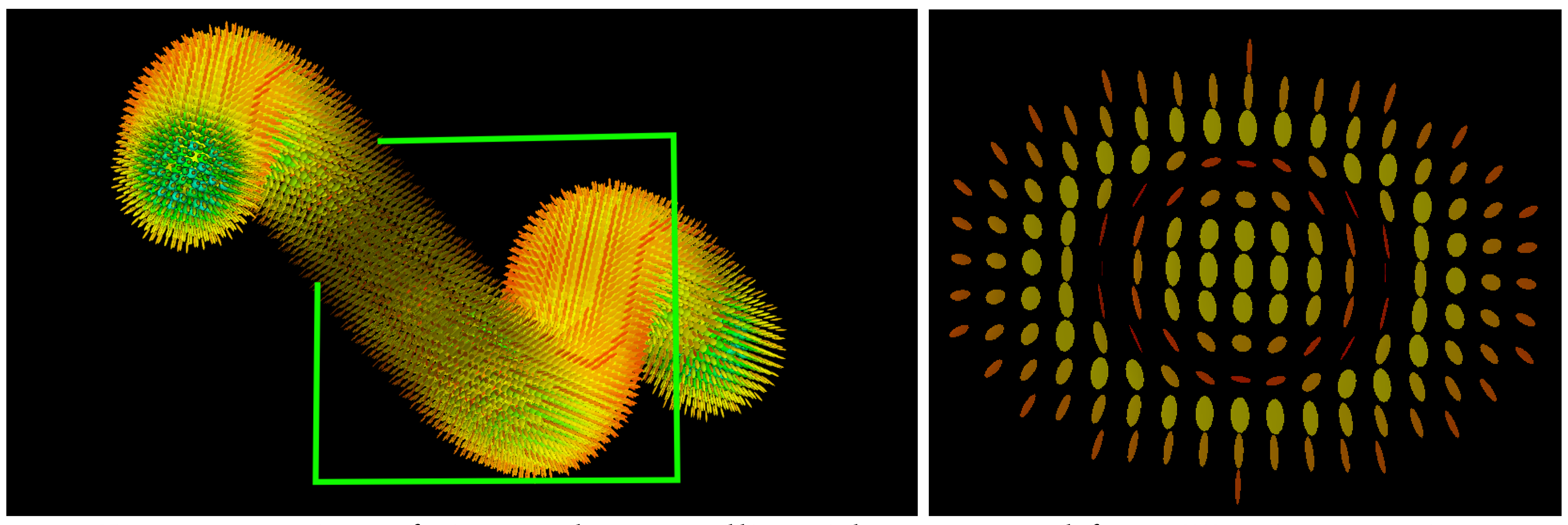
The direction $\vec{t_i}$ defines the normal vector to the next extraction plane and $\vec{t}_{i-1}$ the previous one. According to Aylward [4] it is necessary recover from local discontinuities.

Preprocessing + HT



Canny edges Circle detection

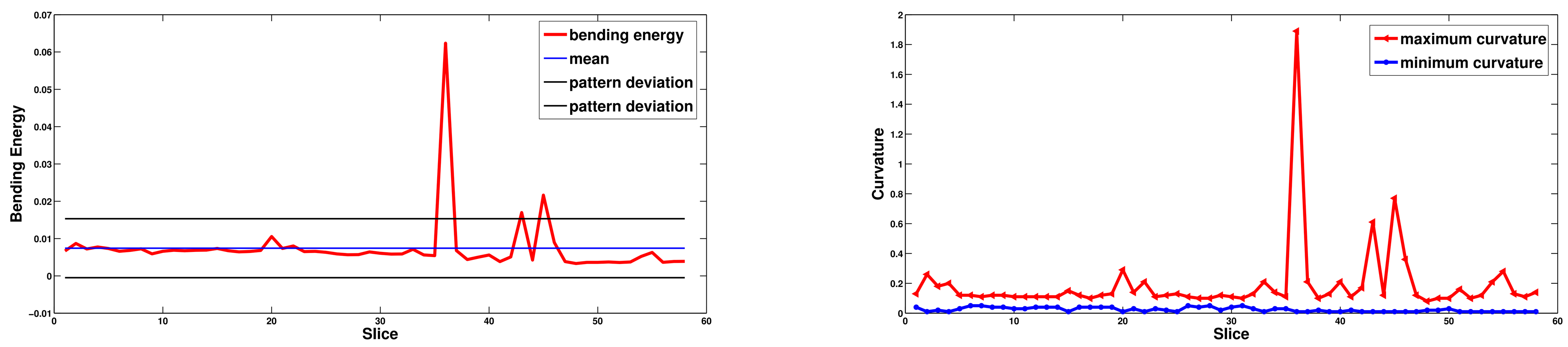
Eigenvalues Representation



Representation of eigenvalues as ellipsoids computed from Hessian matrix.

Bifurcation Analysis

Sequence of vessel cross-sections in a bifurcation point.



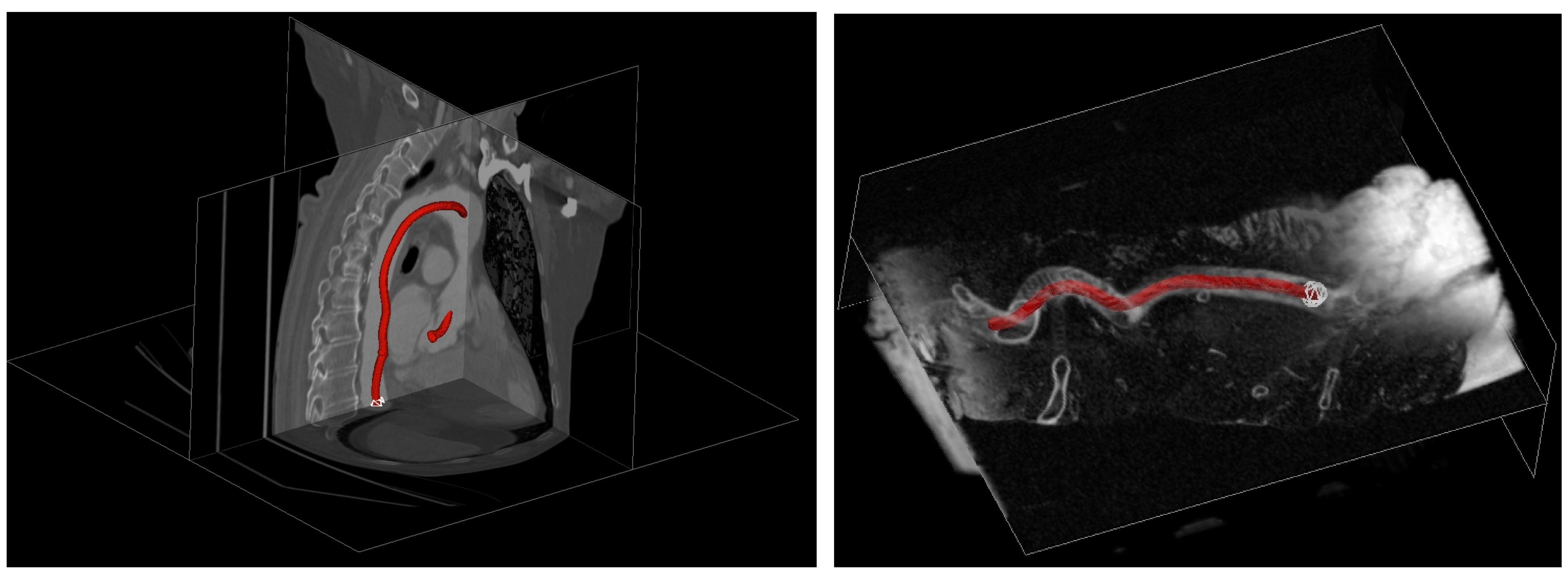
Descriptors extracted from vessel cross-sections.

Results and Evaluation - real and synthetic images

The methodology was developed using C++ language and auxiliary libraries such as *Visualization Toolkit* and *Insight Toolkit*.

Sinusoids used as synthetic data.

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



Thoracic aorta trajectory in CTA image 0.78x0.78x0.80mm. Coronary artery trajectory in MRA image 0.25x0.25x0.25mm.

Discussion and Conclusions

We proposed a semi-automated method to detect and track vessel centerlines in CTA and MRA images. During the tracking process, we analyze probable bifucation points. 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.

References

[1] 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.

[2] O. Wink, W. Niessen and M. Viergever Multiscale Vessel Tracking. In *IEEE Transaction on Medical Imaging*, 2004.

[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.

[4] 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.