TOWARDS ROBUST AND FAST VESSEL EXTRACTION FROM MRA IMAGES

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Introduction

- An increasing demand for sophisticated tools to characterize the integrity and functional state of vascular networks from different imaging modalities has emerged.
- Currently available tools are time-consuming and limited in their ability to assess the state of vascular architectures,
- There is a need for developing robust and fast computer-based techniques for extracting vessel trajectories as well as estimate their diameters.

Purpose

- To investigate a technique based on the well-known Hough Transform (HT) to dynamically estimate the trajectory and vessel diameter without resorting to time-consuming multiscale techniques [1].

Methodology

The proposed tracking method consists of successive executions of the above steps to extract a vessel trajectory [2].

1.Initialization

- The tracking method starts by the selection of a seed point in an image plane perpendicular to the vessel tangent.

2.Preprocessing

- Anisotropic Diffusion filtering
- Morphological Opening and Subtraction operation
- Edge detection using Canny filter

3.Tracking

- Compute vessel scale information using HT.
- The vessel direction is computed from Hessian matrix as in [3].
- The direction t_i defines the normal vector to the next extraction plane and t_{i-1} the previous one.

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

4.Bifurcation Analysis

- Each vessel cross-section contour is extracted and represented as a spline.
- From these splines, curvature-based measures are computed for detecting the bifurcation points.

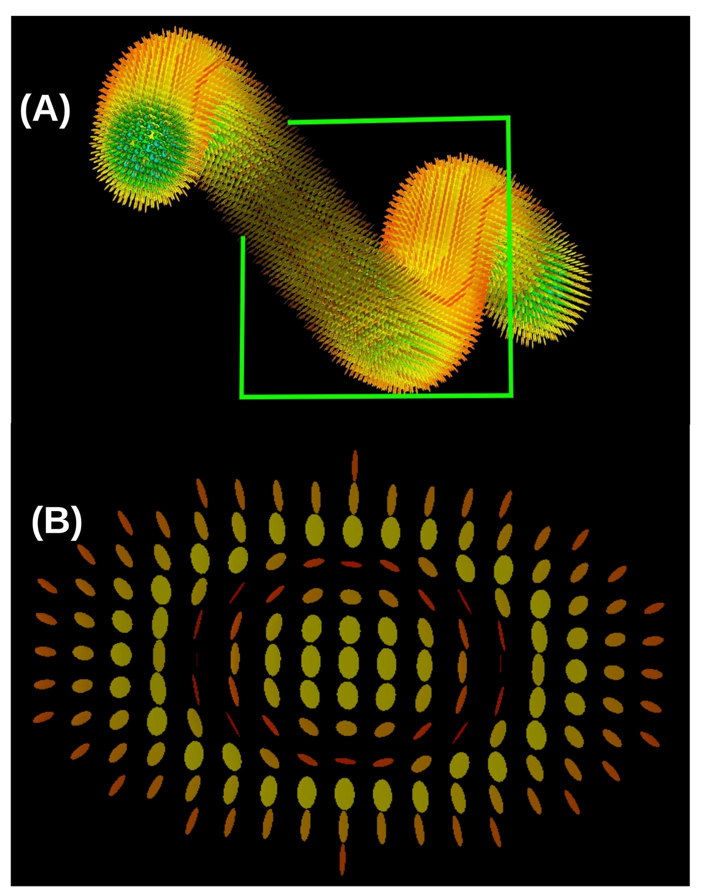

Fig. 1 (A) Ellipsoidal field representing the Hessian information throughout a synthetic vessel segment. Green rectangle indicates the cross-section for depiction of image structure in vessel locations. (B) Vessel exterior, interior and boundary representation by Hessian-based ellipsoidal field.

Scheme Overview

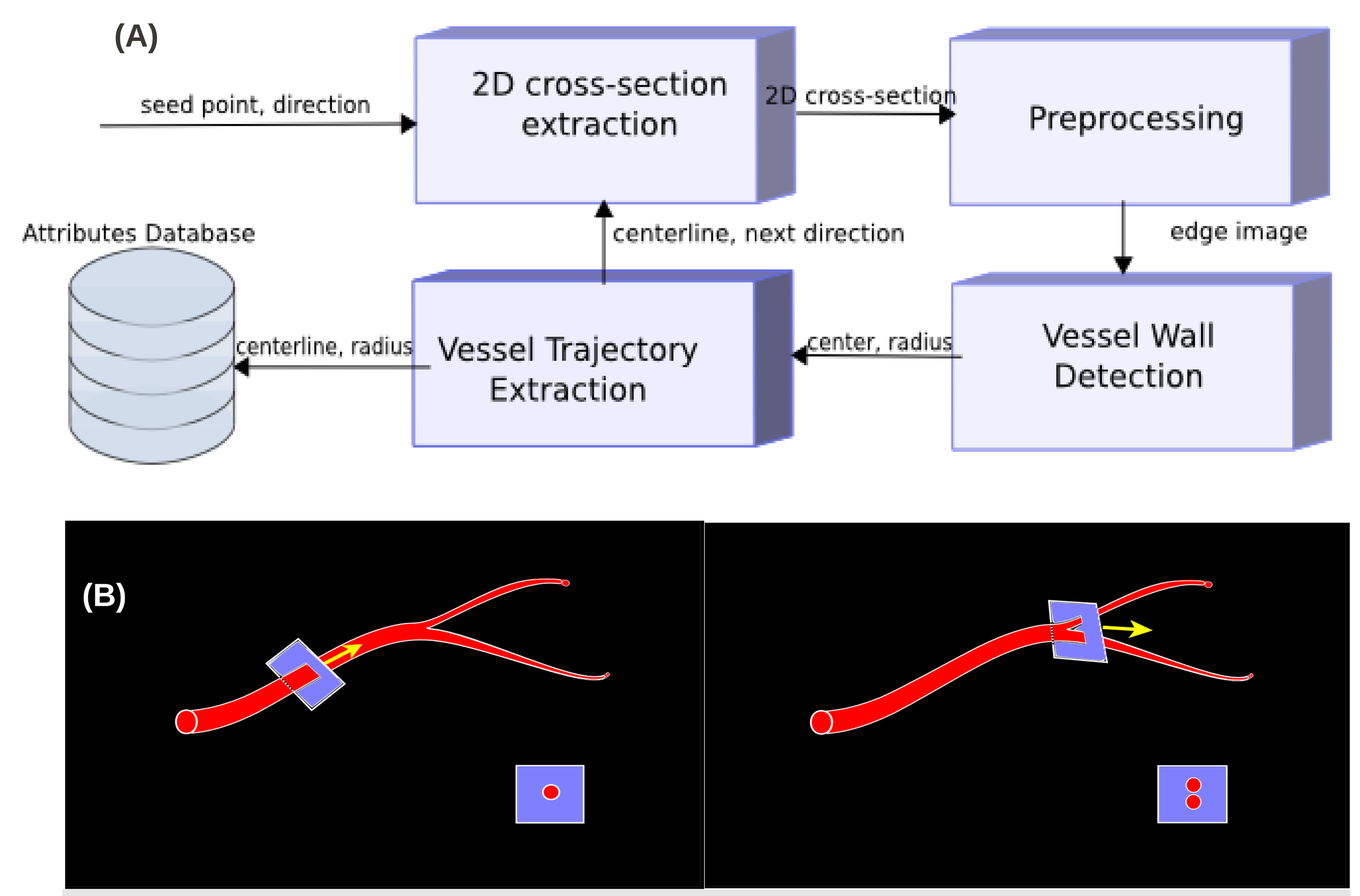

Fig. 2 (A) Flowchart of the methodology. (B) Cartoon depiction of the orthogonal plane extraction in absence and presence of bifurcations.

Results

- The methodology has shown to work well under significant amounts of noise using the synthetic dataset with high curvature trajectory and with several branches.
- Synthetic vessel images: resolution of $1mm^3$ and size 128x128x128.
- MRA of a human brain was acquired on a 3.0T scanner using a T1-FFE sequence with TR/TE=25/3.15ms, with resolution $0.39x0.39x0.5mm^3$ and size 512x512x290.
- For our set of synthetic images, the average distance to the ground-truth centerlines is 1.5 mm.

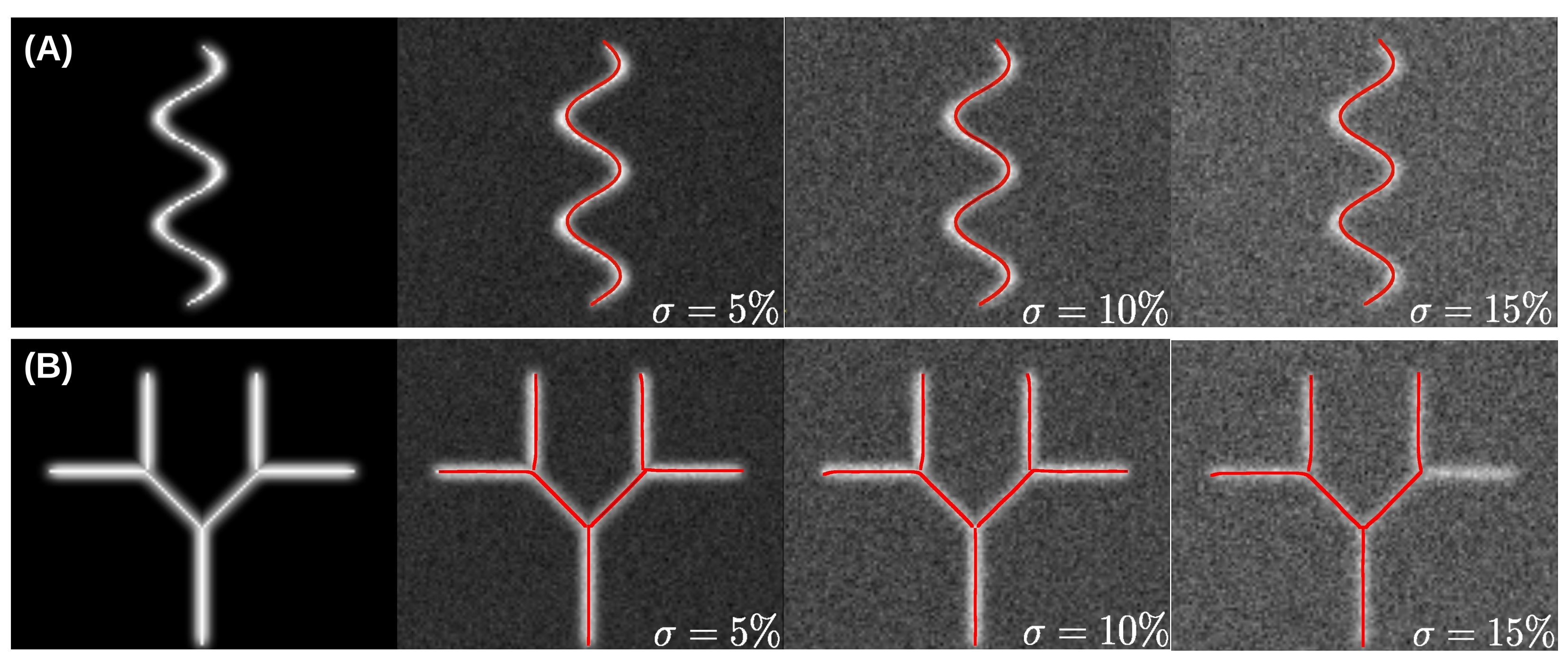

Fig. 3 (A) Sinusoidal synthetic vessel image without noise and with increasing levels of Gaussian noise (σ) combined with tracking results. (B) Synthetic bifurcation image without noise and with increasing levels of Gaussian noise (σ) combined with tracking results.

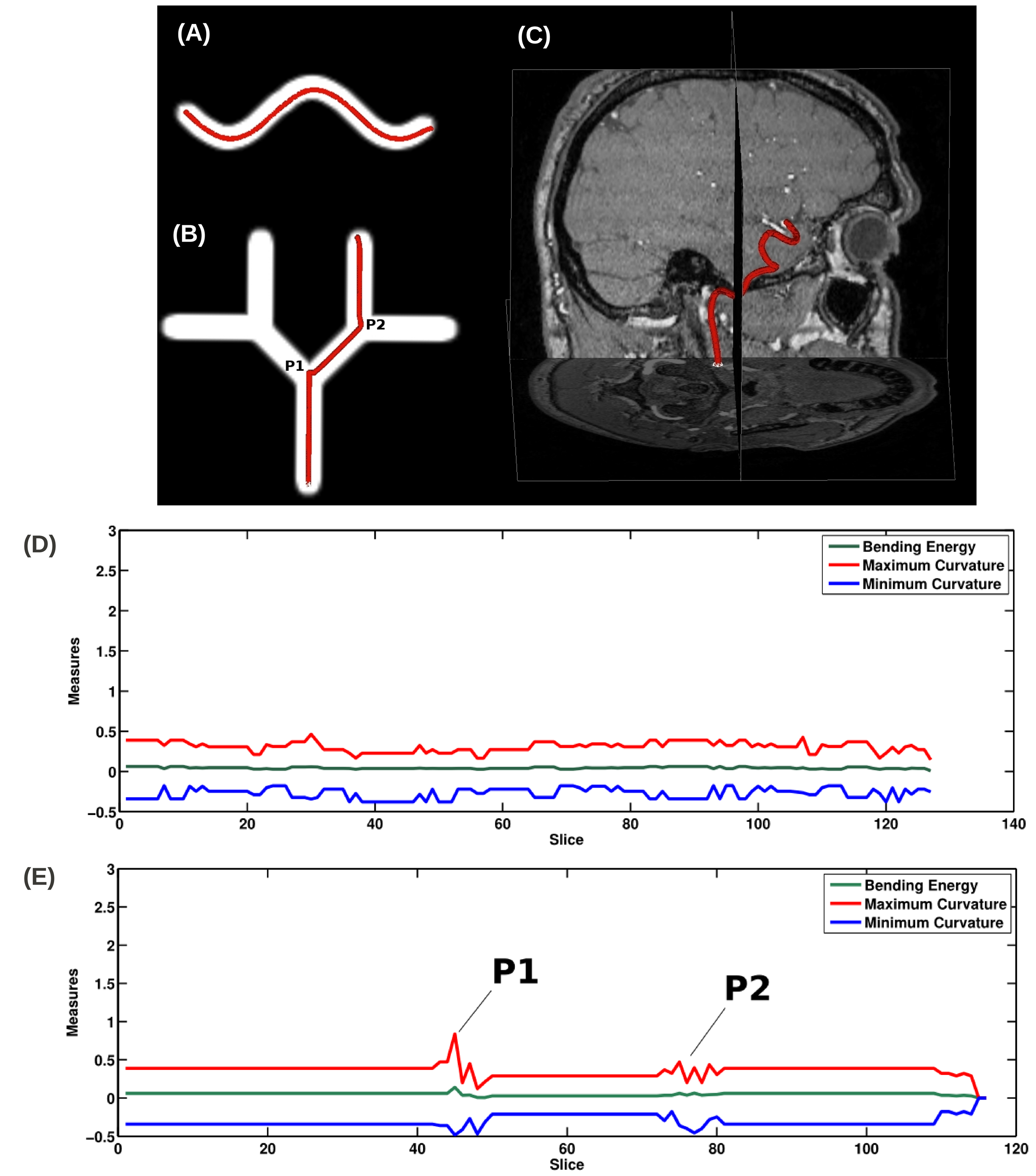

Fig. 4 (A) Synthetic sinusoidal tracking result. (B) Synthetic tree-like tracking result. (C) Brain MRA dataset and results from tracking a carotid segment. (D) Cross-section curvature analysis of (A). (E) Cross-section analysis of (B). Locations P1 and P2 indicate bifurcation points.

Conclusions

- We have proposed a semi-automated method to detect and track vessel trajectories in MRA.
- The novelty of this study is the use of HT to define the seed point for tracking and detecting the vessel scale without resorting to multiscale analysis technique.
- In spite of presence of noise, a mean diameter can be established.
- Future work will focus on automatic bifurcation handling using analysis of curvature of the vessel profile at the cross-section.

References

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