A Neighbourhood Search Feedback for Conary Artery Centerline Tracking

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Introduction

Coronary artery centerline is important for Computed Tomography Angiography (CTA) visualization to diagnose Coronary Artery Diseases (CAD). Many coronary artery centerline extraction algorithms have been proposed in recent years. However, there are risks of fail in vessel tracking if unable to locate the roots and error propagated during tracking process.

Purpose

We propose a method of coronary artery centerline tracking with neighbourhood search feedback mechanism after seed point optimization to overcome the problem of error propagation. The key notion is to provide a feedback mechanism in the likelihood function as a self-optimization algorithm.

Method

A) Image Preprocessing

Image preprocessing is performed to enhance the vessel's region and ensure that the vessel's property is robust for tracking process. Image preprocessing consists of two steps: (1) Vessel Enhancement (figure 1) and (2) Piecewise Segmentation (figure 2).

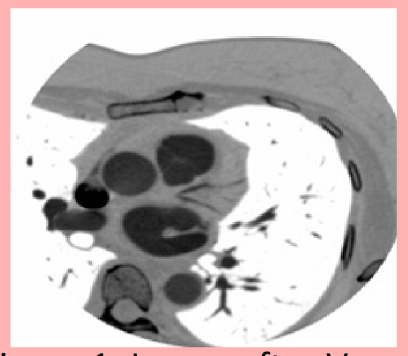

Figure 1: Image after Vessel Enhancement.

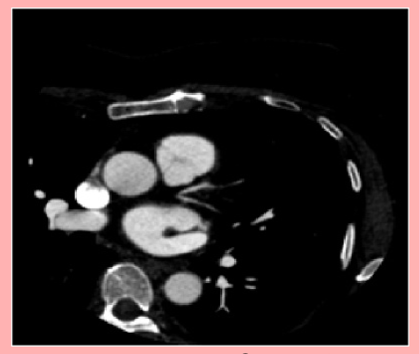

Figure 2: Image after Piecewise Segmentation.

In particular, the image is convolved by Laplacian of Gaussian (LoG) in Vessel Enhancement and segmented by a piecewise function.

B) Centerline Tracking

Given a volume of processed images, our proposed algorithm start with a seed point to generate a set of tree points. We defined 3 proximity radius for difference purposed: (1) Vessel proximity radius (R_V), (2) Non-vessel proximity radius (R_{NV}) and (3) Turning proximity radius (R_T). Seed Point Optimization is deployed to reduce possibility of error propagation from initial defined seed point (figure 3).

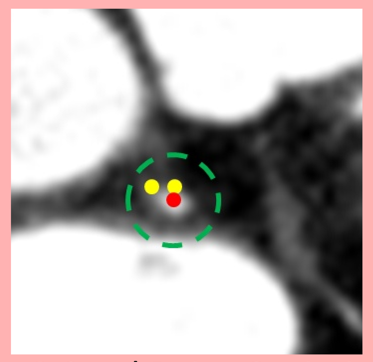

Figure 3:Seed Point Optimization.
The red point is the optimized point within a proximity (green).

Our work is inspired by Forward-Backward Correlation algorithm proposed by Wang [1] which he used to overcome the problem from traditional template-based tracking. We modify and named as Backward-Forward Correlation Verification.

In the centerline tracking loop, the previous tree point is always propagated to current slice as reference location by Minimum Cost Path Approximation. Before register the point as current tree point, verification by Backward-Forward Correlation Verification is performed to reduce the error propagation.

First, we perform *backward-current* correlation correction (figure 4) for approximated point from Minimum Cost Path Approximation [refer to our paper for more detail explanation].

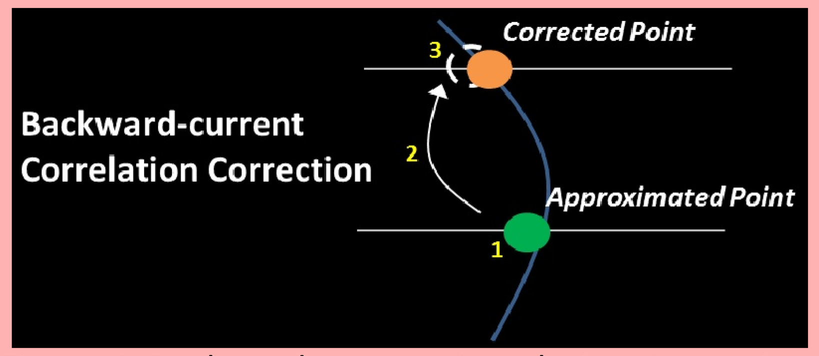

Figure 4: Backward-current Correlation Correction.

Then, perform *forward-current* correlation verification (figure 5) to verify points by correlation matching.

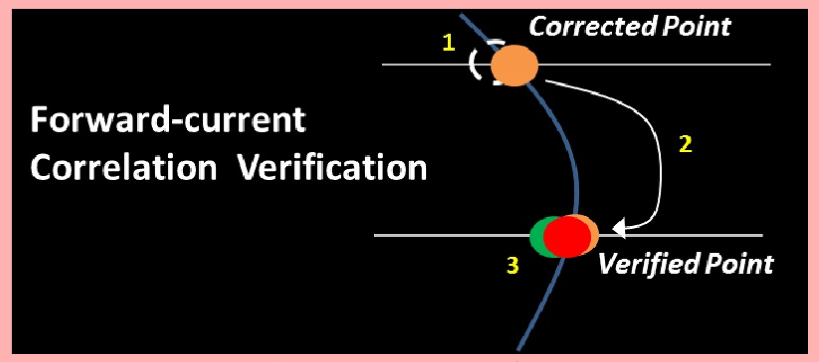

Figure 5: Forward-current Correlation Correction.

The tracking process loops until the distance between two consecutive tree points more than defined threshold R_{NV} and not background pixels.

Results

We compare the results from proposed method and minimum cost path vessel tracking without feedback mechanism (NFM) to evaluate the capability of proposed method in error propagation reduction. Two evaluation measures are calculated:

1. Capability to track the vessel of reference

$$\Omega_1 = \frac{TP_m + TP_r}{TP_m + TP_r + FP + FN} \times 100\%$$

2. Average distance error of the estimated centerline

$$\Omega_2 = \frac{TotalDist}{TotalPts}$$

Table 1:Experimental results from 16 dataset.

Measures	*NFM*			*Proposed Method*		
	Min	Max	Average	Min	Max	Average
Ω_1 (%)	3.3	92.4	50.0	22.7	88.5	67.6
Ω_2 (mm)	0.33	1.04	0.57	0.31	0.81	0.52

Improvement in **Capability to track vessel from reference standard** = 17.6%

Reduction in **Average distance error of estimatedcenterline from the reference standard** = 0.05mm.

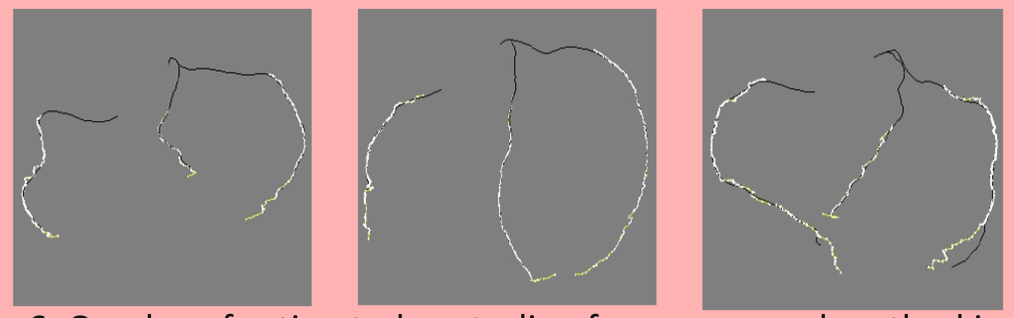

Figure 6: Overlay of estimated centerline from proposed method in white color and reference standard in black color from 3 dataset.

Conclusion

The results provide evidence whereby the neighbourhood search feedback mechanism has the potential in reducing error propagation. However, modification of feedback mechanism is required for different tracking algorithm. Besides, improvement of algorithm is needed to enhance the feedback mechanism.

Reference

[1] X.Wang, Forward-backward Correlation for Templatebased Tracking. Clemson University, 2006.

More Information

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