FAKULTÄT FÜR !NFORMATIK

Faculty of Informatics

Diplomarbeitspräsentation

Coronary Artery Tracking with Rule-based Gap Closing

Masterstudium:
Medizinische Informatik

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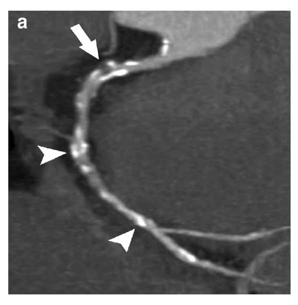
Motivation

Problem:

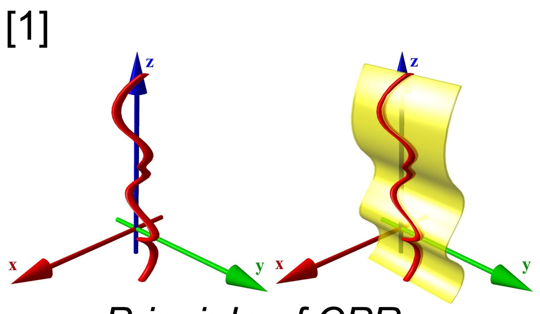
- Coronary artery (CA) diseases are among the leading causes of death in the industrial countries
- Increased demand of robust methods to support diagnosis of radiologists
- Detailed assessment of CA vessels by use of CT angiography (CTA) in extended diagnosis
- Visualization techniques like Curved Planar Reformation (CPR) [1] are based on extracted centerline of the blood vessel lumen

Goal:

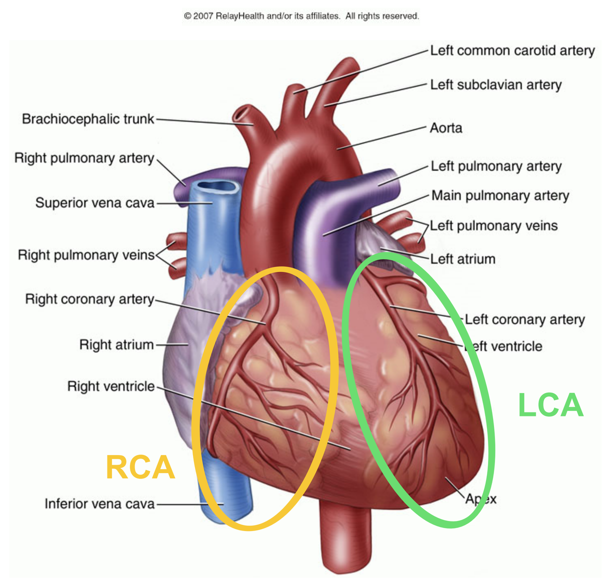
- Accurate and complete centerline extraction of the CA trees
- Use advantages of existing methods



Vessel with present stenoses in CPR



Principle of CPR visualization technique



Anatomy of the heart with highlighted right (RCA) and left (LCA) coronary artery trees.

Basic Approaches

Method of Zambal et al. [2]:

- Top-down approach
- Identify roots of CA tree by local symmetry feature
- Tracking of CA trees by iterative matching of cylindrical shape models

\+ Very accurate centerline

\- Vessels terminate prematurely in areas of low contrast

Method of Bauer et al. [3]:

- Bottom-up approach
- Extract centerlines using gradient vector fields
- Link centerlines based on distance and orientation to each other

\+ High overlap due to linking over areas of low contrast

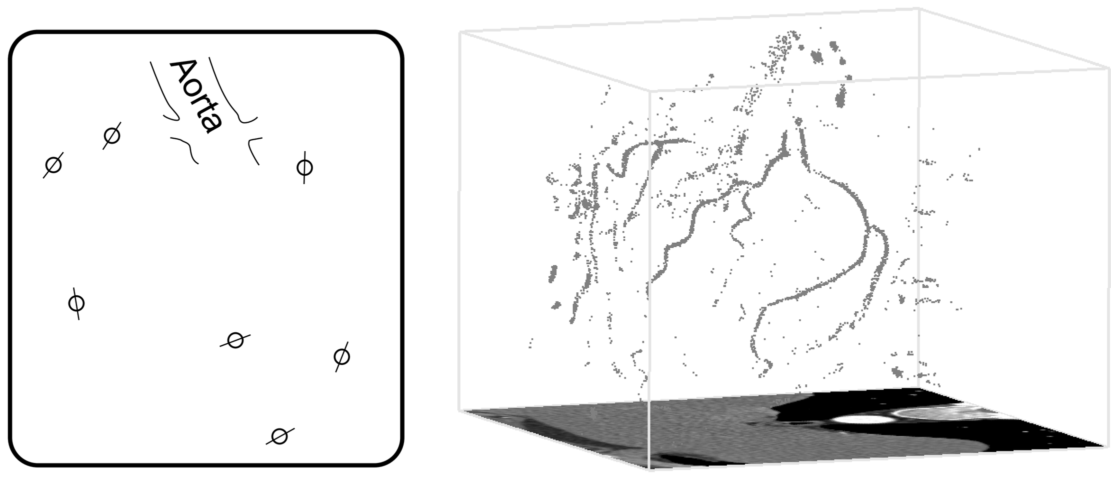
\- Lower accuracy than Zambal et al. [2]

Novel approach:

- Combination of the highly accurate tracking method of Zambal et al. [2] with segment linking similar to Bauer et al. [3]

Coronary Artery Tracking Framework

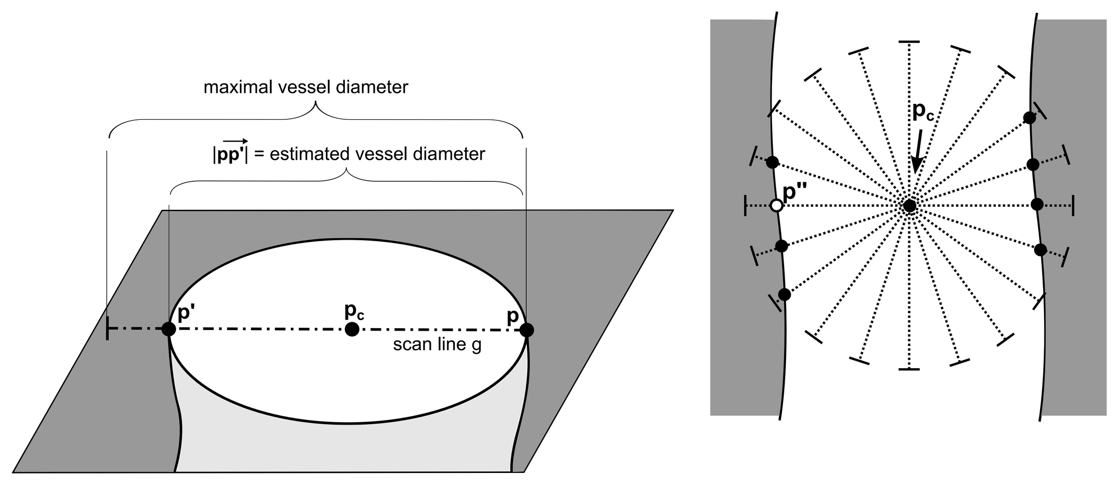
Phase I: Seed calculation



***Output:** Initial seeds for vessel segment tracking, schematic (left) and on CTA dataset (right).*

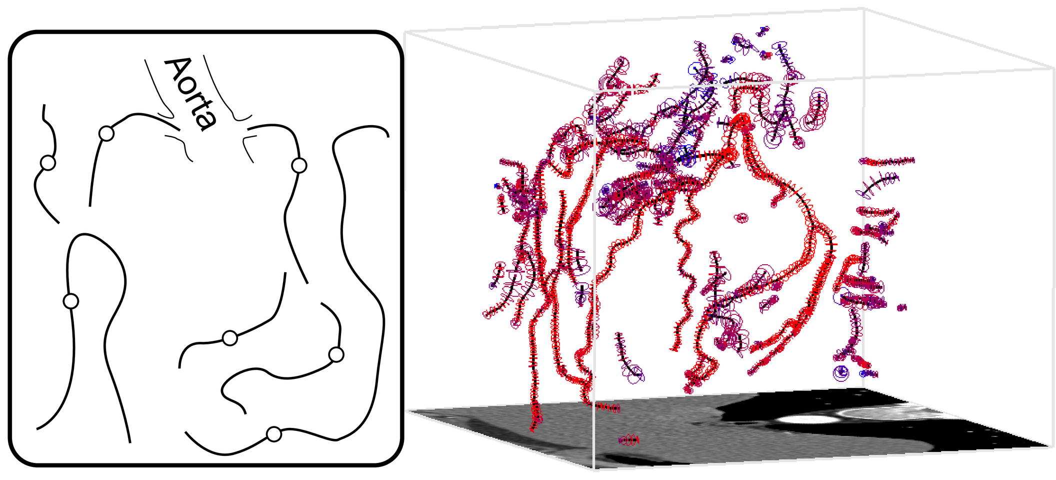
Method:

- Estimate vessel profiles at each position in dataset
- Use ray casting based on gradients at vessel surface



Ray casting for estimating diameter (left) and orientation (right) of vessel profiles

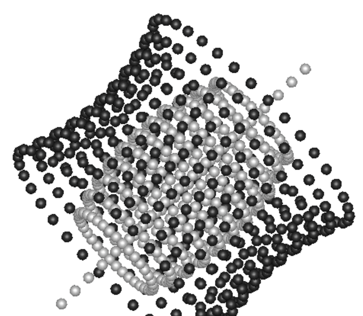
Phase II: Tracking of vessel segments



***Output:** Set of unconnected vessel segments, schematic (left) and on CTA dataset (right).*

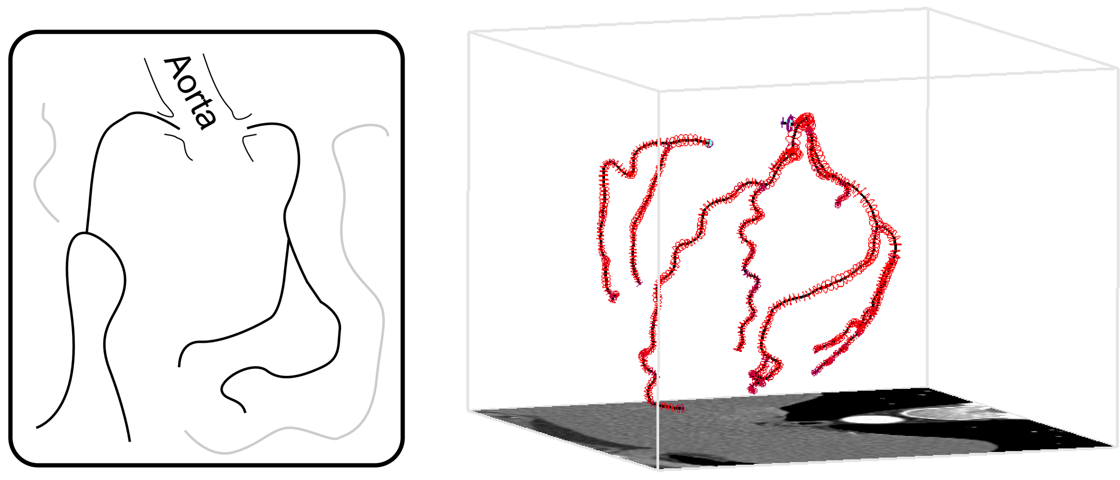
Method:

- For each seed, track vessel segment in both directions without branching, until termination criterion is reached
- Use cylindrical shape model and histogram-based vessel evaluation function of Zambal et al. [2]



Cylindrical shape model [2]

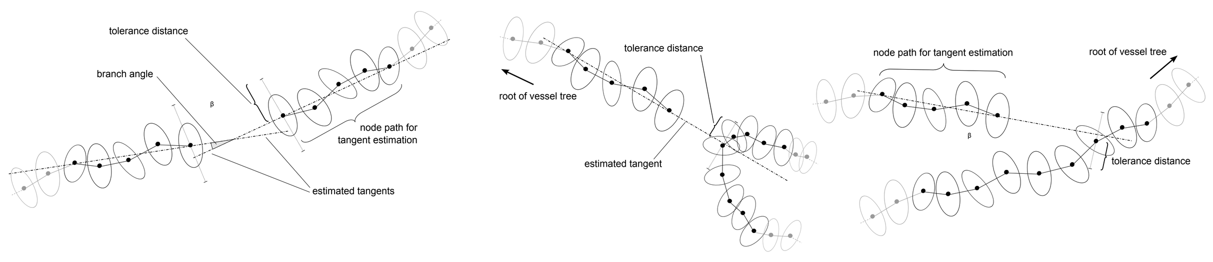
Phase III: Tree growing



***Output:** Vessel segments connected to full CA trees, schematic (left) and on CTA dataset (right).*

Method:

- Connect vessel segments to create complete CA vessel trees, starting at user-defined root points
- Apply a set of connection rules on the tree, until no further vessel segment can be connected
- Connections are found according to rule parameters (segment distance, angle between estimated segment trajectories, etc.)



Three types of connection rules: end-to-end points (left), end-to-inner points (center), inner-to-end points (right)

Results

Evaluation Framework:

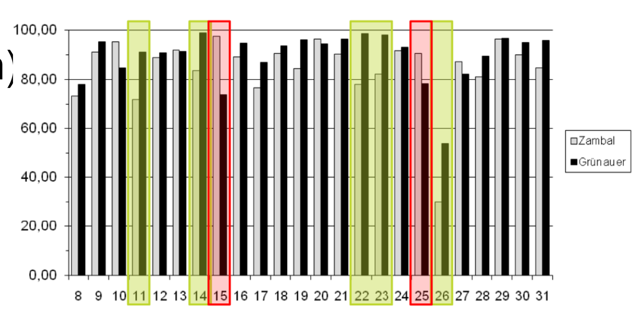
- "Rotterdam CA Algorithm Evaluation Framework" [4]
- 24 CTA datasets, each provided with four expert annotated centerlines

Measures:

- Ability to track the complete vessel (Overlap OV)
- Accuracy inside vessel (AI)

Results:

- Very precise AI (0.24 mm)
- High OV (89.5%)

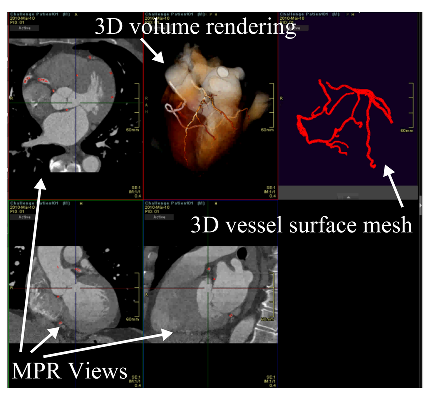


OV results compared to approach of Zambal et al.: significant improvements (green) and degradations (red) on 24 CTA test sets

Integration in clinical software

Functionality:

- (Semi)-automatic tracking of the CA trees at user-defined root-points
- Single-click tracking of vessels at manually placed seeds



GUI of the developed CA tracking plug-in

3D vol. rendering without segmentation (left), heart and blue colored CAs (center), transparent heart with opaque CAs (right)

Conclusion

- Novel approach achieves high overlap in combination with very high accuracy
- BUT: Balancing of tree growing rules is a critical task

Future work:

- In-depth evaluation of potential paths during vessel segment tracking
- Calibration of connection rules
- Automatic root-point selection

References:

[1] A. Kanitsar, D. Fleischmann, R. Wegenkittl, P. Felkel, and M. E.Gröller. CPR - Curved Planar Reformation. In *IEEE Visualization 2002*, pages 37–44, 2002.
[2] S. Zambal, J. Hladuvka, A. Kanitsar, and K. Bühler. Shape and appearance models for automatic coronary artery tracking. In *The Midas Journal, MICCAI Workshop - Grand Challenge Coronary Artery Tracking*, 2008.
[3] C. Bauer and H. Bischof. Edge based tube detection for coronary artery centerline extraction. In *The Midas Journal, MICCAI Workshop - Grand Challenge Coronary Artery Tracking*, 2008.
[4] M. Schaap et al. Standardized evaluation methodology and reference database for evaluating coronary artery centerline extraction algorithms. *Medical Image Analysis*, 13(5):701–714, 2009.

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