Fast Vessel Centerline Tree Extraction Algorithm

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Abstract

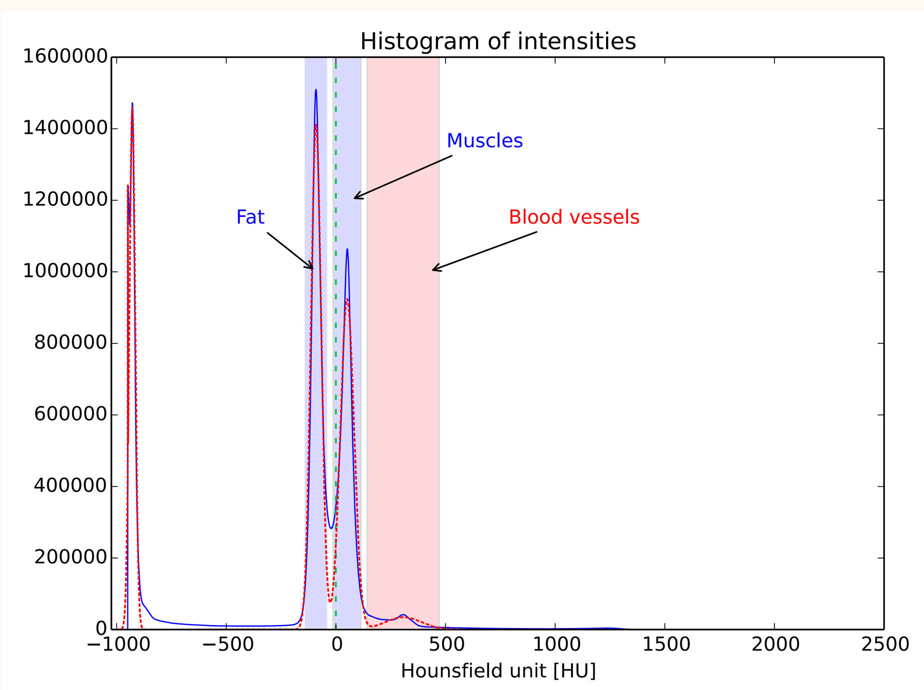
Precise segmentation of vascular structures is crucial for studying the effect of stenoses on arterial blood flow. Segmentation of tubular structures may be facilitated and accelerated by first extracting the centerline tree directly from the grayscale 3D image and then using this as a seed region.

We propose an algorithm for extracting the blood vessel centerline tree from Computer Tomography Angiography images. The algorithm is adapted to the tubular shape of vessels and is fast enough to permit interactive clinical use.

Motivation

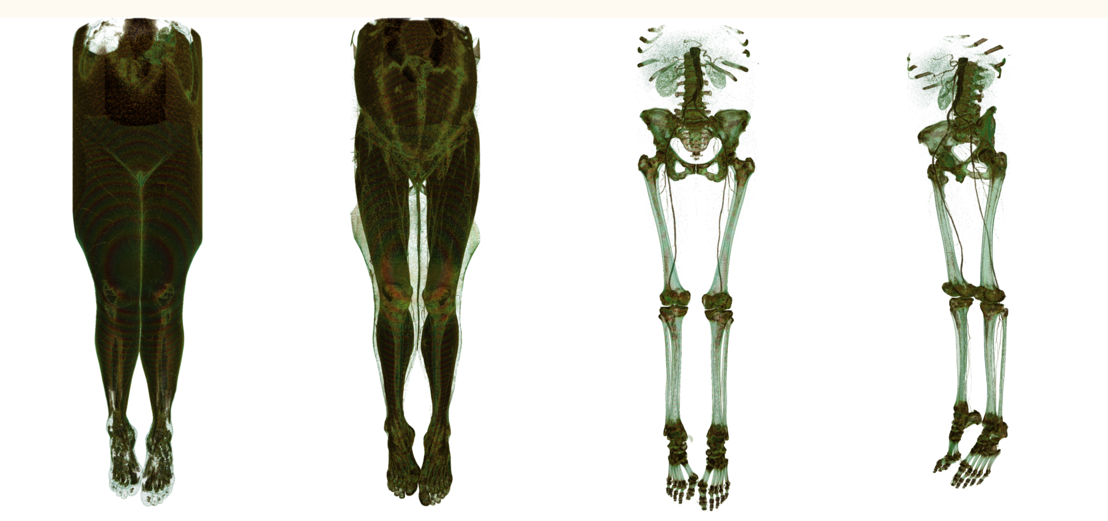
There is a growing need for accurate and fast methods to identify and measure the centerline of arteries, especially in endovascular surgery. Our vessel centerline tree extraction algorithm takes approximately 10 seconds for a 512x512x717 volume on a single cpu core. The algorithm provides initial step for fast vascular segmentation.

Parameters selection



We have developed a way of automatic tuning all parameters and constants used throughout the algorithm.

Our method is based upon fittings of Gaussian curves to the image histogram. It allows us to find proper intensities for different human tissues. These information is needed for setting the parameters correctly.



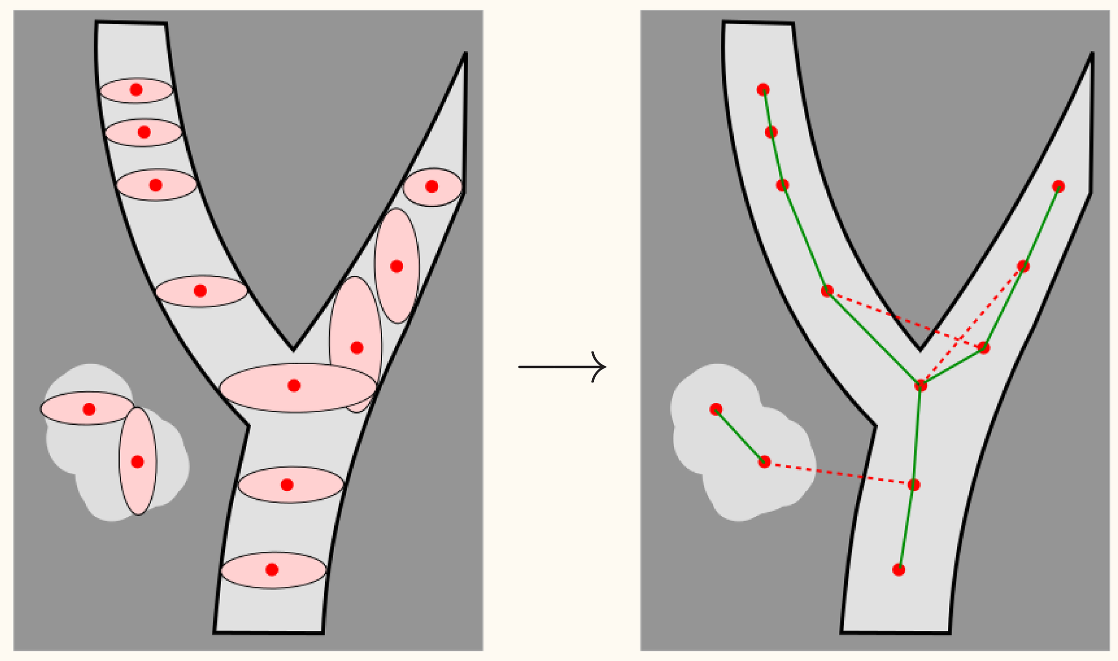
Hounsfield values [-158,-44],[-12,114] and [143,471] are displayed, based on the automatic classifier

Method

The proposed method consist of two main parts:

1. We **detect** centrally located voxels that are part of the tubular vessel structure.
2. We **connect** them and create a vascular tree graph structure.

The algorithm uses two passes. During the first pass, only reliable parts of the vessel structure is detected. During the second pass, additional small scale structures are added to the structures. Structures found, not belonging to the vessels, are removed in a final anatomy-based analysis.



Nodes are detected (left) and connected (right). Dashed lines will not be connected as their connection criteria are not fulfilled.

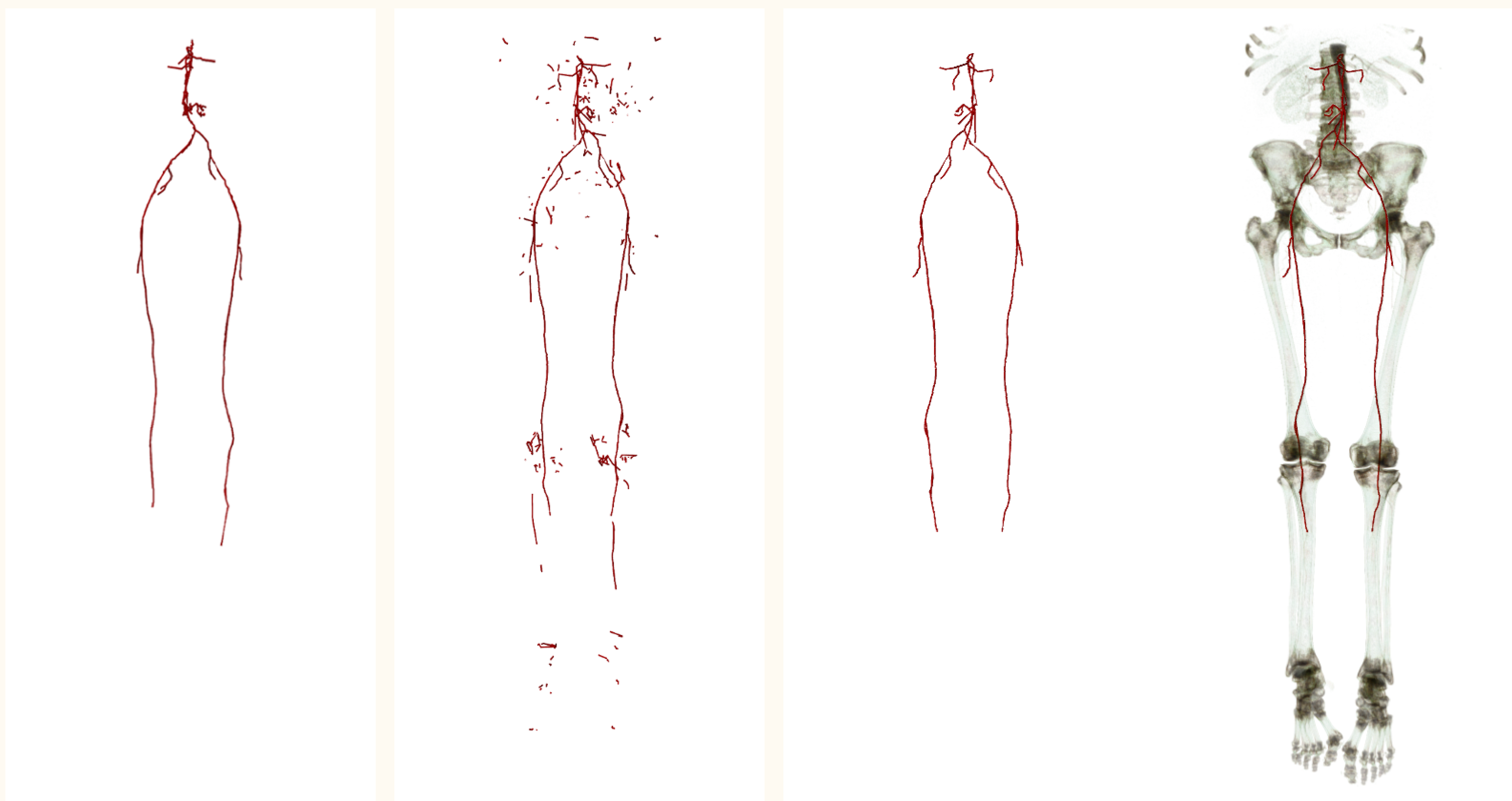
1. Detection of centernodes

- The volumetric data is scanned by all axis-oriented 2D planes
- Using simple filter points related to vascular structure
- Points fulfilling all vascular criteria are considered to be part of the tubular vessel structure and are used as graph nodes

2. Connection of centernodes

- The vessel nodes are linked together based on the connection criteria, gradually building up the centerline tree
- For each tree node the implicit length of all its branches is calculated
- All insufficiently long branches are removed.
- Final vessel centerline tree structure is obtained

Results



Rough centerline *Fine centerline* *Resulting centerline*

We tested the method on different CTA datasets. The proposed method is still the subject of ongoing research showing promising results at this stage.

The main advantage of the proposed method is its speed. Finding a centerline in CTA volume of a matrix size 512x512x717 voxels and bit depth 16 bits takes 12.9s. The algorithm is also fully automatic, which is a important property for medical use.