BLOOD VESSEL SEGMENTATION

RESULTS

1. Histogram of diameters

Image1.tif

- the range of the diameters --> [1, 20.8806];
- the mean value of the diameters --> 8.7464
- 1688 measurements have been considered.

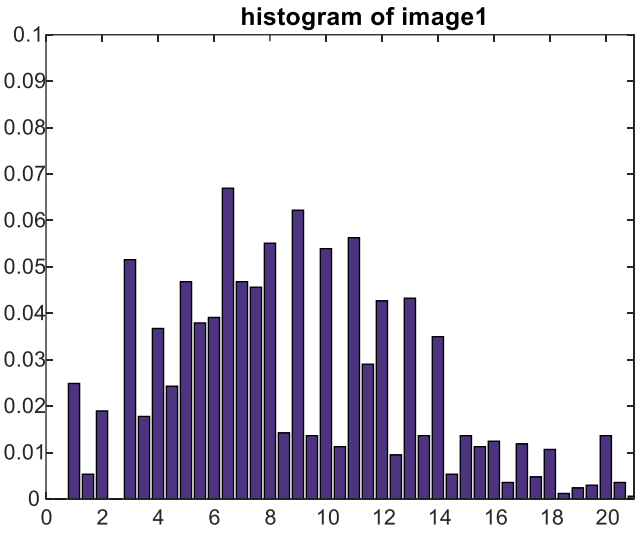
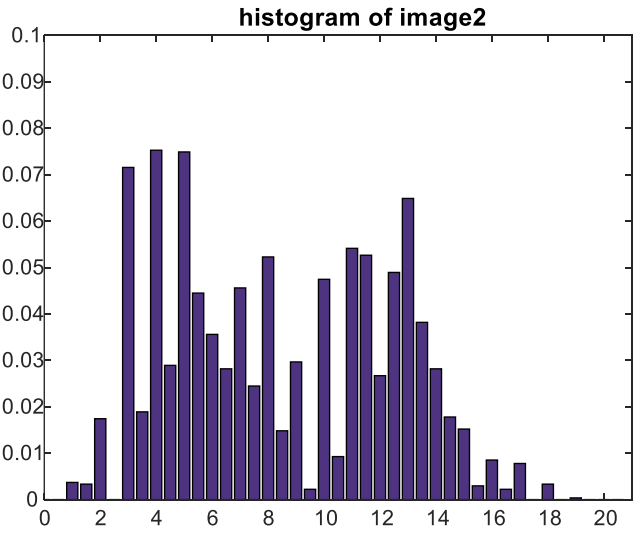


Image2.tif

- the range of the diameters → [1, 18.7883];
- the mean value of the diameters --> 8.5008
- 2697 measurements have been considered.



- Quantization has been done in a range of 0.5 in both histograms.

BUGS

The script has been written to work for those two images without given any error. However, the results are not perfect. There are a few points to improve:

1. Segmentation

The solution requires a robust segmentation. In this solution, the low level image processing techniques such as dilation, erosion and filtering have been used for segmentation. This segmentation works effectively (still not perfect) for the second image. However, the first image suffers from the illumination problem. Thus, a segmentation method that is insensitive to the illumination changes should be applied. Suggested solutions are the use of spectral clustering or region growing.

2. Tracking the vessels

There are a few points to mention:

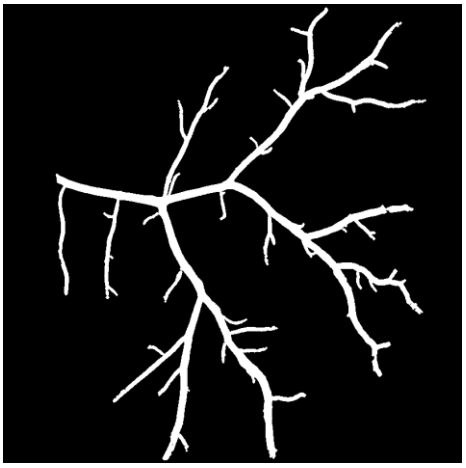
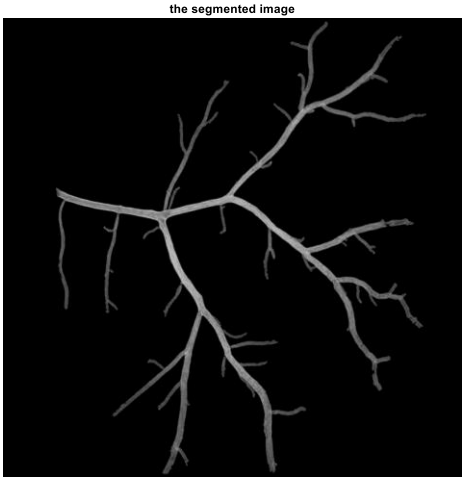
- Tracking the vessel takes a long time because of the fact that the solution tracks and calculates the diameter in every point (nearly 2000 points).
- The solution cannot measure the diameter in every point because sometimes the edge points don't overlap with the diameter line.
- A suggested solution to these problems:
    - A certain number of measurements in one line is calculated and averaged. Later, these average value can be weighted by the length of the line while adding to the histogram.
- Tracking the vessel is sometimes not correct i.e. image1.tif because of the segmentation problem.

3. The size of the diameters

Although the diameter has been calculated using the pixel distance, it does not refer to actual size of the diameter. A reference measurement should be given to calculate the real distances.

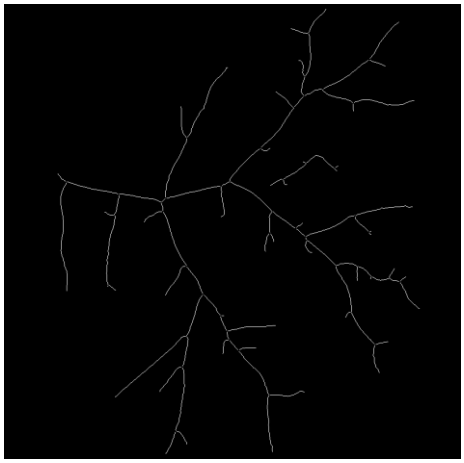
DETAILED EXPLANATION OF THE METHOD

4. Segmentation

- Selection of the green channel from RGB image
  - green channel
    
- Thresholding to a binary image (BW – black and white)
- Sharpening and Gaussian filtering
- Erosion and dilation followed by finding the connected components
- the mask
  
  the segmented image
  

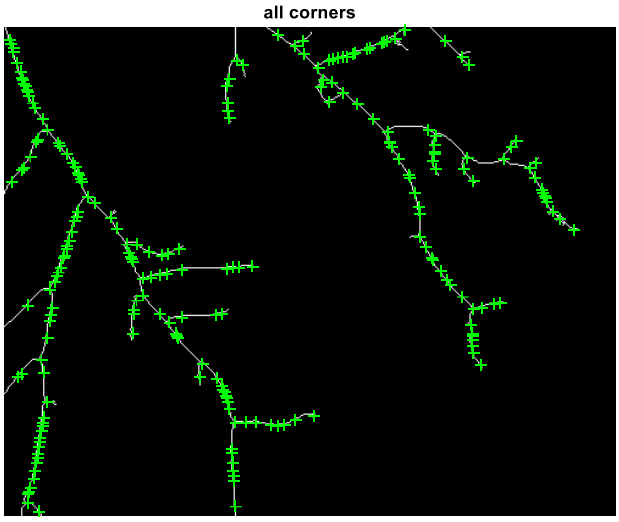
5. Structure of the vessels

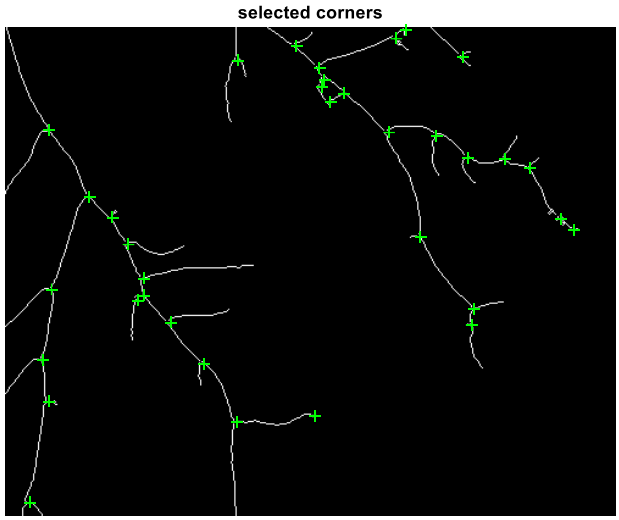
- Thinning the mask to obtain the middle lines of vessels

- 

6. Corner detection

- Harris corner detection
- A method to discard false corner detections
  - Based on the assumption that there should be three different directions in a corner point.
  - Use a filter → [1,1,1;1,0,1;1,1,1];
  - If the filtered region has 3s and 4s, it means it is a branch point (corner point).

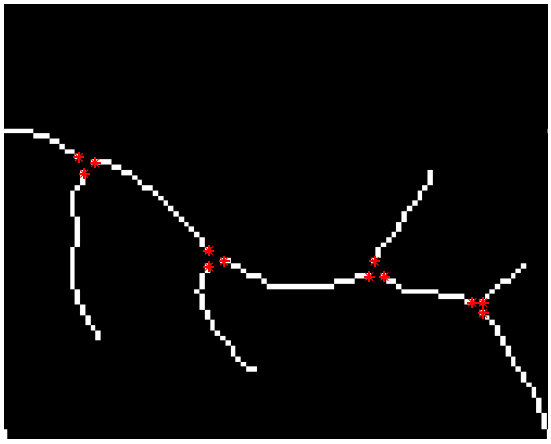
- 



7. Direction of the blood vessels

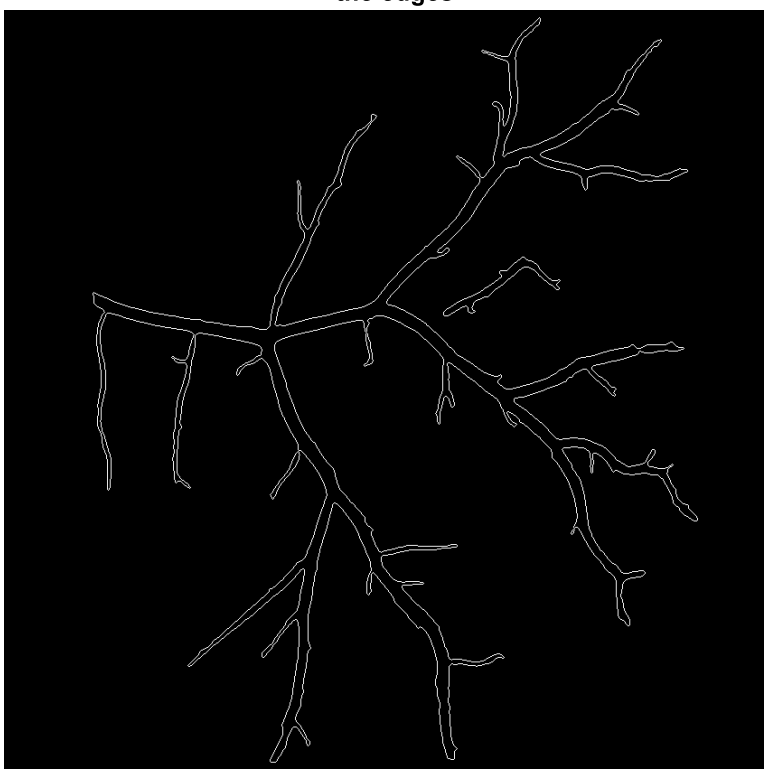
- Find the branch direction towards bifurcations

- directions in a branch point



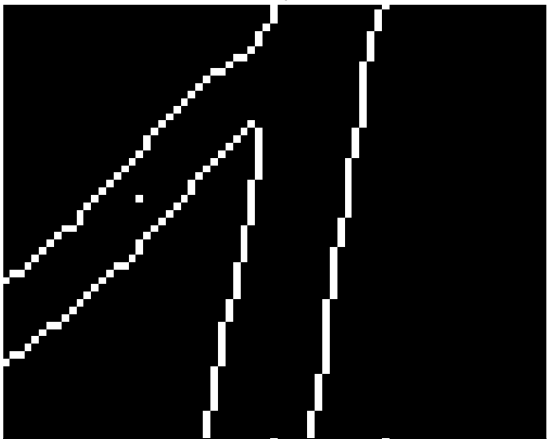
8. Calculation of the diameter (when it bifurcates)

- Find edges of the vessels
  - the edges



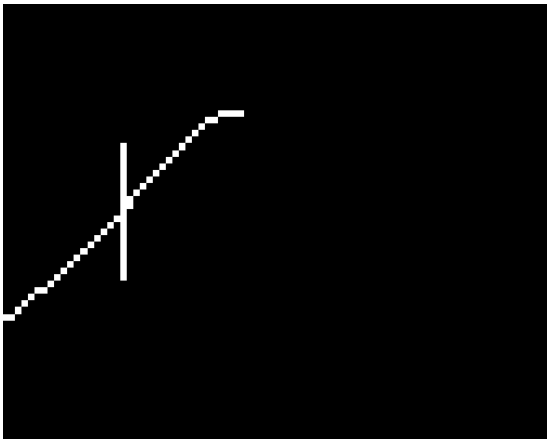
  - instant vessel

  - instant point

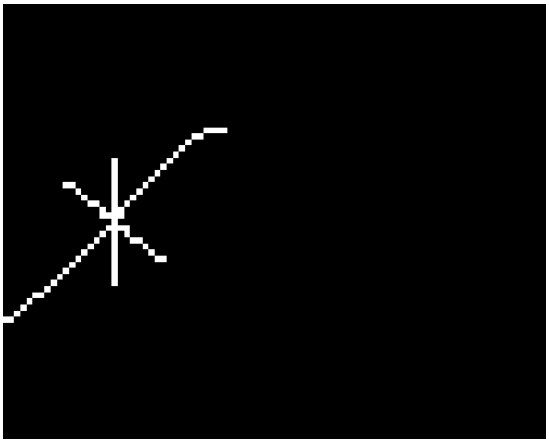


- maskSLE

- maskSL



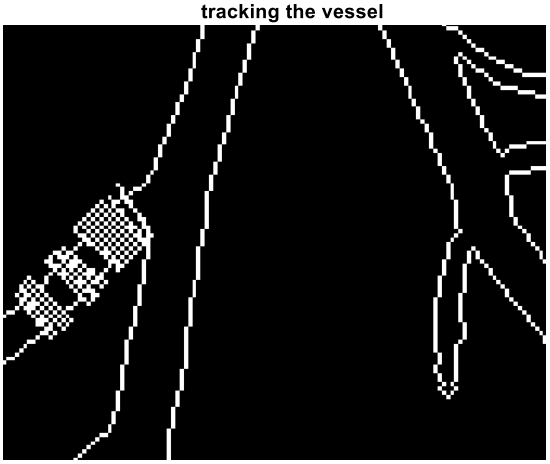
- The diameter line needs to be perpendicular to the center line.
- maskSLrot



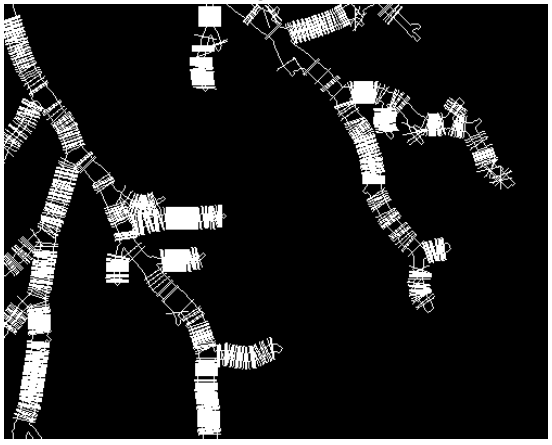
- maskRE

9. Tracking the blood vessels

- Tracking the vessel through the line point
- tracking the vessel

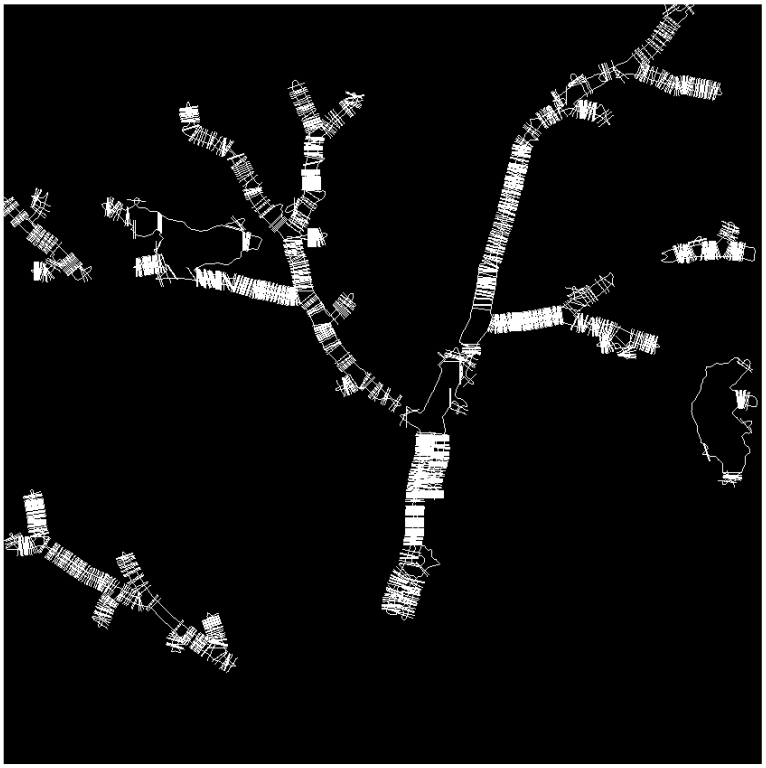


- tracking the vessel



- Some of the rotated lines cannot intersect with the edge points. Those ones will refer to no distance.

tracking the vessel - image1



tracking the vessel - image2