

Project on brain artery analysis

Li Chen

1. Aim

Evaluate brain artery (focusing on anterior cerebral circulation) based on topological structure and normalized intensity of voxel in vessel region to (1) Tell possible effect of aging shown in brain vessel (2) Judging image quality from different sequence (3) Detecting characters that appear in certain type of patients.

2. Approach

Built a semi-automatic Brain Artery Feature Extraction Tool (BAFET) to analyze images and extract features. BAFET (now V0.6.0) is built on Far-sight toolbox (open sourced vessel tracing system, C++) after adding additional 3596 lines, and deleting 415 lines. Main libraries in BAFET include Qt, ITK, VTK, VNL.

3. Data

168 cases of TOF from CROP (CBIR)

8 cases (twice scan) of TOF and Snap from Culprit Plaque (VIL)

14 cases (twice scan) of TOF and Snap from WALLI (VIL)

4. Procedure

(1) Image Acquisition: Sort and rename files from database for management and easier for BAFET to read

(2) Preprocessing: Resample for isotropic resolution. Threshold. Invert intensity and select intensity region (for Snap images). Crop to decrease calculation.

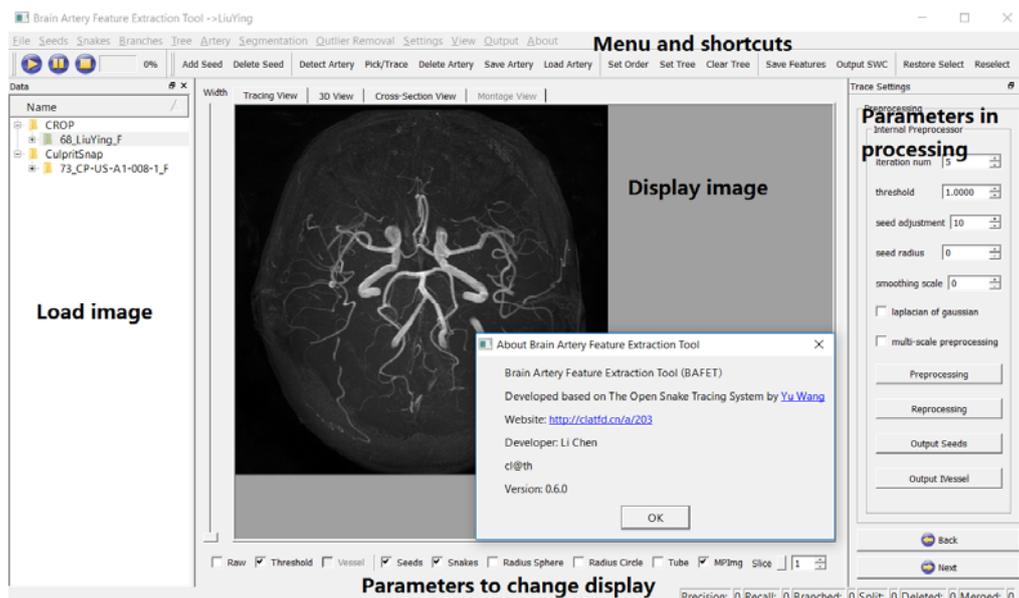
(3) Vessel Tracing: Core function in Far-sight. Find salient seeds from Frangi's vesselness measure using Gradient Vector Flow of images. Trace vessels according to seeds by "Open-curved Snake" (a revised Active Contour Model).

(4) Vessel modification: Edit traces (add, split, merge, delete, create branches) to form a vessel tree.

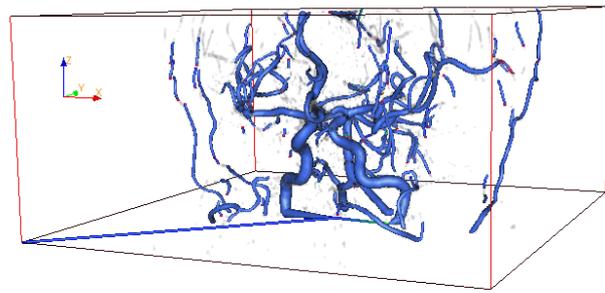
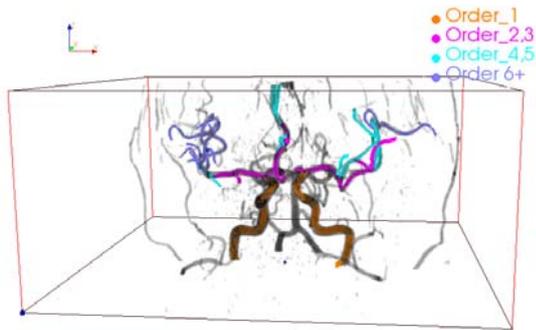
(5) Feature extraction: Divide vessel tree in region according to "Order" (structural rank) and output 28 features (Length, Volume, #Bifurcations, etc. in global and each region) from vessels.

Note:

- Intermediate data (traces, seeds, vessel images) can be saved and re-edited afterward.
- In average, it takes about 3 minutes to automatically generate vessel traces, 5 minutes to manually edit.
- MIP (mIP for Snap) view (zoom), 3D view (rotate and zoom) and cross-section view (at a point) are available as methods to see 3D images. Raw image, Thresholded image or Vesselness image are available as image sources.
- The output of tracing result is in SWC format (3D points location with radius and connection)



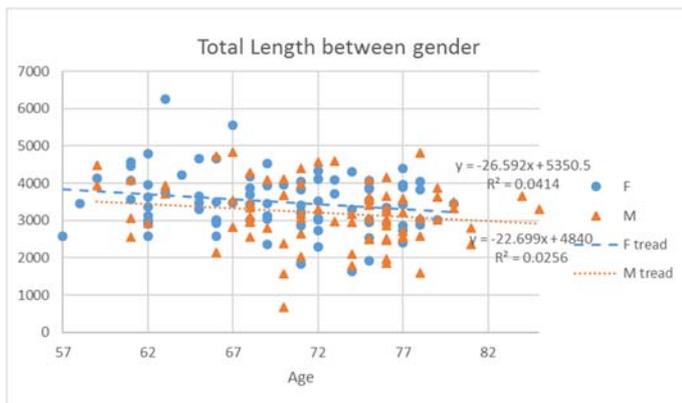
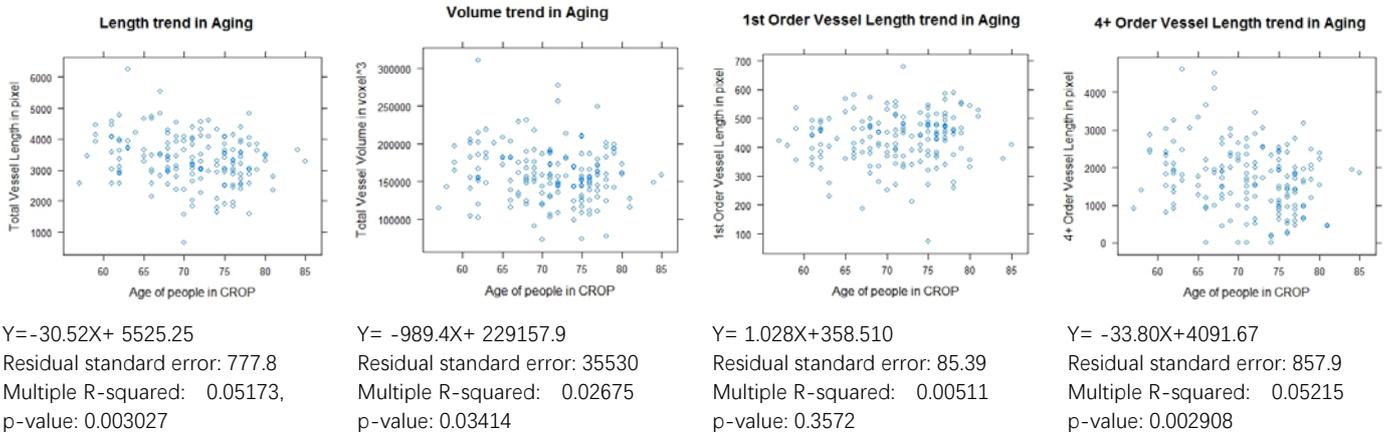
GUI of BAFET



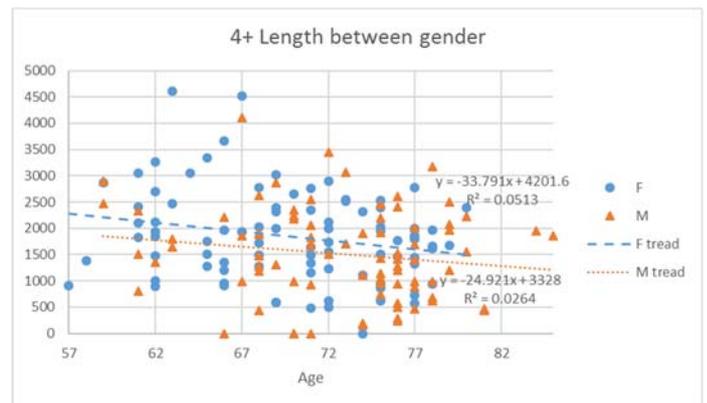
Left: Result of tracing (paint in different color according to "Order")
 Right: Tubular display of vessels (each node has its radius information)

5. Preliminary results

(1) On CROP data



Male = $-22.699X + 4840$, $R^2 = 0.0256$
 Female = $-26.592X + 5350.5$, $R^2 = 0.0414$

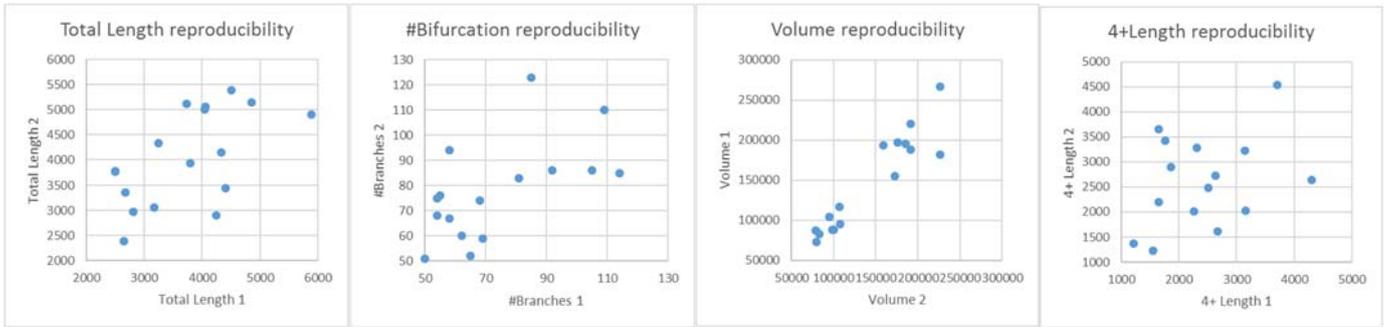


Male = $-24.921X + 3328$, $R^2 = 0.0264$
 Female = $-33.791X + 4201.6$, $R^2 = 0.0513$

Possible assumptions:

- There is a decrease trend on total length, volume and some other features through aging.
- The small vessels (4+ "Order") decrease faster than main arteries (1st "Order")
- Men's brain vessels appear a few years older than women's

(2) Testing reproducibility on repeated scan on Culprit Plaque data



ICC: 0.5984043
CV: 23.91296

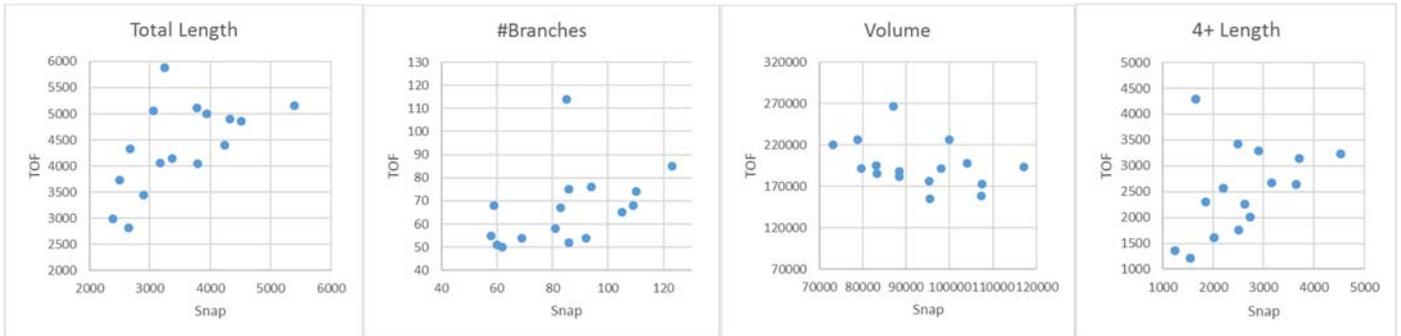
ICC: 0.5935547
CV: 26.79504

ICC: 0.9292275
CV: 39.03784

ICC: 0.314703
CV: 36.93821

We can find some features are more stable and trustful than others.

(3) Testing difference in TOF and Snap data from Culprit Plaque



Possible assumptions:

- Vessel length is higher in TOF than Snap
- Number of bifurcation is lower in TOF than Snap

7. Future work

- Test WALLI data
- Intensity Normalization: Auto or manual select white matter and chewing muscle as two reference points to rescale intensity for the whole image
- Find landmarks and label main vessels in name according to structure. Locating circle of Willis.
- Comparing features from healthy and ill people.
- Visualizing plaque on vessel in BAFET

8. Brief Instruction to use BAFET

- (1) Open TracingSystem.exe. Expand database and select image folder on the left (such as "68_LiuYing_F") wait until threshold image appear. Press "Next".
- (2) Press "Preprocessing" to calculate seed points, wait a while until red dots appear on image. (This step is memory consuming). Click and "Add seed" to add new seeds, "Shift" hold and select region to choose seeds to "Delete Seed". Press "Next".
- (3) Press "Tracing", wait until green traces all appear. Switch to 3D view to have better view. Select two main arteries and click "Detect Artery". Select a trace and click "Snakes->Split Snakes" to split in convergence point and circle of Willis. Select two traces and click "Snakes->Merge Snakes" to merge traces. click "Set Order" to create vessel tree, and click on root point (0,0,0) and click "Set Tree". Press "Next".
- (4) Click "Output Raw SWC" to save traces, "Output SWC" to save tree, "Save Features" to save feature in csv.

9. For more information

Project webpage: <http://clatfd.cn/a/201>

Download BAFET V0.6.rar (60.9MB) <http://clatfd.cn/data/BAFETV0.6.rar>

Thanks!