Application of Vascular Model Toolkit (VMTK) for Coronary arteries

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Abstract

Background

Functional evaluation of coronary arteries involves study of their 3D shapes and diameters. Segmentation of vascular structures from 3D-Computerized Tomographic Angiogram (CTA) images can be achieved by using VMTK. This gives: (1) a polygonal surface model of vascular structures having centerline based geometric quantities and (2) compute centerlines and Maximal Inscribed Sphere Radius (MISR) of branching tubular structures (Voronoi image).

Methods and Results

VMTK module integrated in Slicer3 is used as it allows use of other Slicer3 modules for processing of images. We use: VesselEnhancement, EasyLevelsetSegmentation and Centerlines modules for study. Right and left coronaries (RCA,LCA) are processed separately. Either Frangi or Sato vesselness is used for vessel enhancement of volumes. Vessel enhanced image is used as input for EasyLevelsetSegmentation. Centerline module is run to get final model and its Voronoi image. Automatically generated centerlines data gives MISR. Position of each point on a image (in X,Y and Z axes) is found using probe-position filter of Paraview. For five normal (3 female, 2 male) CTA images of heart, average of ten points each on proximal, middle and distal segments of arteries is calculated. The average MISR of RCA, LAD and left circumflex (LCX) are (in mm): proximal (1.00,1.11, 0.98), middle (0.97, 0.97, 0.85), and distal (0.95, 0.92, 0.80). Average diameters for RCA (1.94), LAD (2.00), and LCX (1.64) is compared with traditional CTA measurements proving its accuracy.

Conclusions

The geometric details of coronary artery obtained from VMTK are superior to those of unprocessed CTA images. These images show: centerlineprep (vascular wall), Voronoi image (vascular lumen) and centerlines. It generates large (~5000) MISR data points for each coronary. Its computational analysis allows segmentation of small (1.2 pixels/diameter) vessels. Data presented here

suggests VMTK analysis of coronaries is superior to conventional studies.