Fusion of computed tomography and intravascular ultrasound to obtain human coronary geometry

TU/e technische universiteit eindhoven

Erasmus MC University Medical Center Rotterdam

Fusion of computed tomography and intravascular ultrasound to obtain human coronary geometry

Alina van der Giessen[1,2], Frank Gijsen[1], Jolanda Wentzel[1], Nico Mollet[1], Ton van der Steen[1], Pim de Feyter[1] and Frans van de Vosse[2]

[1] Thoraxcenter, ErasmusMC Rotterdam,

[2] Department of Biomedical Engineering, Eindhoven University of Technology

Introduction

Wall shear stress (WSS) is an important factor in the development and progression of atherosclerosis. To calculate patient specific WSS we need the 3D geometry of the coronary arteries.

Computed tomography (CT) is a 3D noninvasive imaging modality. Unfortunately lumen and wall of coronary arteries are hard to segment due to limited resolution. The gold standard to obtain lumen and wall contours is by intravascular ultrasound (IVUS), however the 3D position of the IVUS images is unknown.

Aim: To develop a method to construct 3D coronary geometries by combining IVUS and CT images.

Material and methods

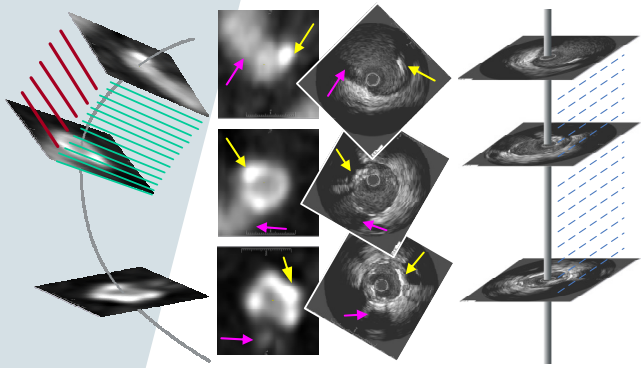
Data acquisition

An IVUS pullback was performed in one or more of the main coronaries of patients eligible for coronary intervention. A 64-slice CT scan was performed shortly before the procedure. Lumen and wall contours are drawn in the IVUS images for a region of interest.

Method

In 6 steps the IVUS contours are positioned in 3D and combined with the CT images.

1. The centerline of the vessel is drawn in CT.
2. Cross-sectional images of the artery are equidistantly generated perpendicular to the centerline at every 0.2 mm.
3. Bifurcations are used as landmarks to match CT cross-sections with the IVUS images. The IVUS images are rotated appropriately.



Left: CT cross-sectional images at 0.2 mm (green) (step 2). Right: IVUS image stack (z-distance ≈ 0.5 mm). Center: matched images with rotated IVUS (step 3). Red lines : resampled CT images (step 4). Pink arrows: side branches. White arrows: calcium.

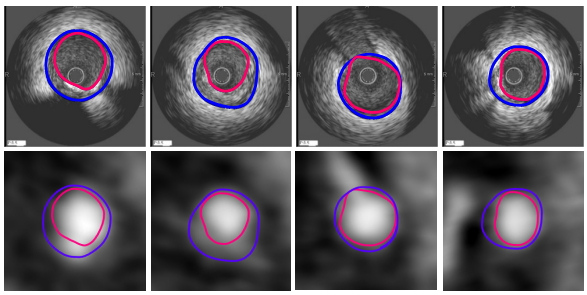
4. Step 2 is repeated however with the number of CT images between the landmarks equal to the number of IVUS images. The IVUS rotations are interpolated between the landmarks. Every IVUS images now corresponds to a CT cross-section in 3D.
5. The matched IVUS contours are placed in 3D.
6. Part of the CT lumen is replaced by the IVUS lumen contours.

Results

The method is developed up to step 6. A right coronary artery is presented as a first case.

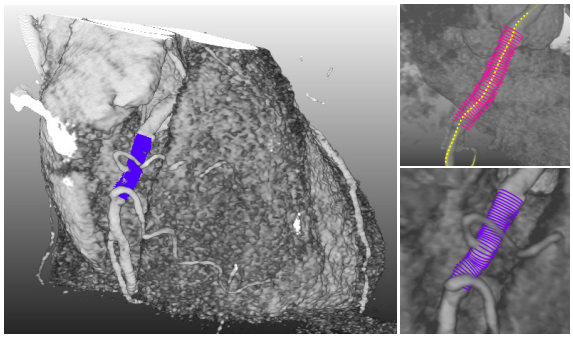
2D Evaluation

IVUS images with corresponding CT images in which the IVUS contours (pink lumen, blue wall) are placed.



3D Evaluation

IVUS contours (pink lumen, blue wall) 3D positioned in the CT image. Also the centerline (yellow) is shown.



Discussion

When validated, this method will be used:

- as a clinical tool to establish the accuracy of manual contour drawing of lumen and wall in CT by comparing them to IVUS contours.
- to generate fused geometries of IVUS contours and CT, in which WSS can be calculated and related to wall parameters.