Introduction:
Coronary artery disease is the most common cause of death in the Western world. It results from the accumulation of plaques within the walls of the arteries that supply the heart muscle with oxygen. It is therefore of utmost importance to image (the progression) of coronary artery disease. Due to the continuing technological improvements of CT scanners, CT angiography has become a promising modality for imaging the coronary arteries. Compared to the traditional imaging modalities, such as X-ray coronary angiography and intravascular ultrasound, CTA has various advantages; CTA is not invasive and it provides a true 3D or 4D expression of the coronary artery trees (see Fig. 1). Unfortunately, due to the limited spatial- and temporal resolution, the quantitative analysis of the coronary vessel wall in CT images is subject to improvement. Intravascular ultrasound (IVUS) is an imaging modality using a catheter with an ultrasound probe, which allows monitoring from inside a vessel. IVUS images have a much higher resolution than CT and IVUS can be considered the gold standard for vessel wall imaging. There is quite a large amount of data of coronary artery segments that have been scanned with both CT and IVUS present, and it is therefore very attractive to fuse the images of both modalities to improve interpretation. The presence of the combined information gives us the means to develop much better segmentation methods. Moreover, the 3D spatial information of CTA images may be used to position IVUS information in the 3D coronary tree, which increases the application domain of IVUS.

Goal: The goal of this M.Sc. assignment is to match the IVUS and CT images to combine the complementary analyses. This can be performed in a two-step approach. In the first step vessel segments can be matched using landmark matching in which anatomical landmarks such as bifurcations, calcified plaques and stents are matched (see Fig. 2). To facilitate this (manual) matching, software has already been developed at the LKEB. In figure 3, the result of this matching is illustrated by means of a transversal view of a coronary vessel. In this figure
the vessel segment is matched but the radial information is lost. The movement of the IVUS catheter causes the radial variation in IVUS images and makes it difficult to position the radial components. The second important step to actually compare the contours of the vessel is to translate and rotate the images such that they coincide. We propose to realize this matching by modeling the pullback trajectory of the IVUS catheter. This way, the catheter trajectory can be reconstructed to determine the orientation of the pullback using knowledge about the mechanical constraints of the catheter and information about corresponding anatomical structures (see Fig. 4).

This subject is available for a physics, electrical engineering, or mathematics student with knowledge of image processing, (mechanical) modeling, and with C++ programming skills.

Contact:
Henk Marquering, Ph.D. H.A.Marquering@lumc.nl, 071-5261113
Jouke Dijkstra, Ph.D. Jouke.Dijkstra@lumc.nl, 071-5262270
Laboratorium voor Klinische en Experimentele Beeldverwerking
Department of Radiology, LUMC
Postbus 9600, 2300RC Leiden