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Computerized methodology for micro-CT and histological data inflation using an IVUS based translation map

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ABSTRACT

A framework for the inflation of micro-CT and histology data using intravascular ultrasound (IVUS) images, is presented. The proposed methodology consists of three steps. In the first step the micro-CT/histological images are manually co-registered with IVUS by experts using fiducial points as landmarks. In the second step the lumen of both the micro-CT/histological images and IVUS images are automatically segmented. Finally, in the third step the micro-CT/histological images are inflated by applying a transformation method on each image. The transformation method is based on the IVUS and micro-CT/histological contour difference. In order to validate the proposed image inflation methodology, plaque areas in the inflated micro-CT and histological images are compared with the ones in the IVUS images. The proposed methodology for inflating micro-CT/histological images increases the sensitivity of plaque area matching between the inflated and the IVUS images (7% and 22% in histological and micro-CT images, respectively).

1. Introduction

Acute thrombus formations results to life threatening consequences such us stroke or myocardial infarction. The mechanisms of coronary artery disease (CAD) initiation and progression [1] have been studied for many years [2]. It is well known that plaques at high risk for rupture and thrombus formation are not necessarily those that cause severe stenosis [3,4]. In order to investigate plaque features of vulnerability and changes in their composition an accurate visualization of the vessel wall is needed. Several invasive and non-invasive imaging modalities [5,6] are nowadays available which are major determinant of the clinical outcome [7], and provide the appropriate interventions. Imaging methods, allow assessment of luminal pathology, quantification of plaque burden and characterization of the type of the plaque.

Intravascular ultrasound (IVUS) [8] is currently the most widely used invasive imaging modality which provides high resolution cross-sectional images of the coronary arteries. In IVUS images an expert observer can permit detailed evaluation of the lumen, media-adventitia border and evaluate the plaque composition with a moderate accuracy [9]. To increase the accuracy of IVUS in characterizing the atherosclerotic plaque, several methodologies have been proposed in the literature allowing automated processing of the IVUS frames [10–14]. However, these methods were based on experts annotations and none of them was further validated using histological cross sections, which is considered as the current gold standard in plaque characterization. Therefore, the Virtual histology intravascular ultrasound (VH-IVUS) [15] plaque characterization method was developed and validated based on histology [16]. The VH-IVUS has become the method of choice in IVUS plaque characterization and is widely used in the clinical and research arena nowadays [17,18].

Although histology is considered as the gold standard for atherosclerotic plaque characterization an accurate registration between the histology and IVUS images is needed [19]. Therefore, experts detect anatomical landmarks such as side branches,

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surrounding tissue layout, etc, in both IVUS and histological images. Once the artery histological segments are matched with the corresponding IVUS segments, the histological images are produced. However, histological image extraction is a time consuming procedure having several limitations. The harvested segments are mounted in a paraffin tray, then the pathologist cut the

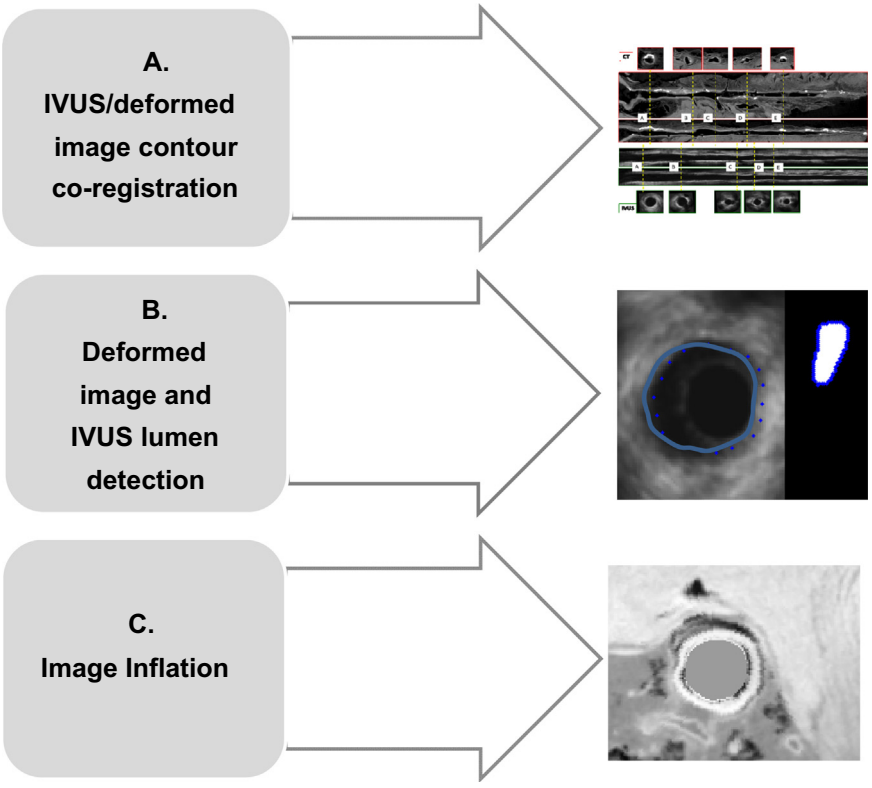

Fig. 1. Schematic presentation of the proposed methodology.

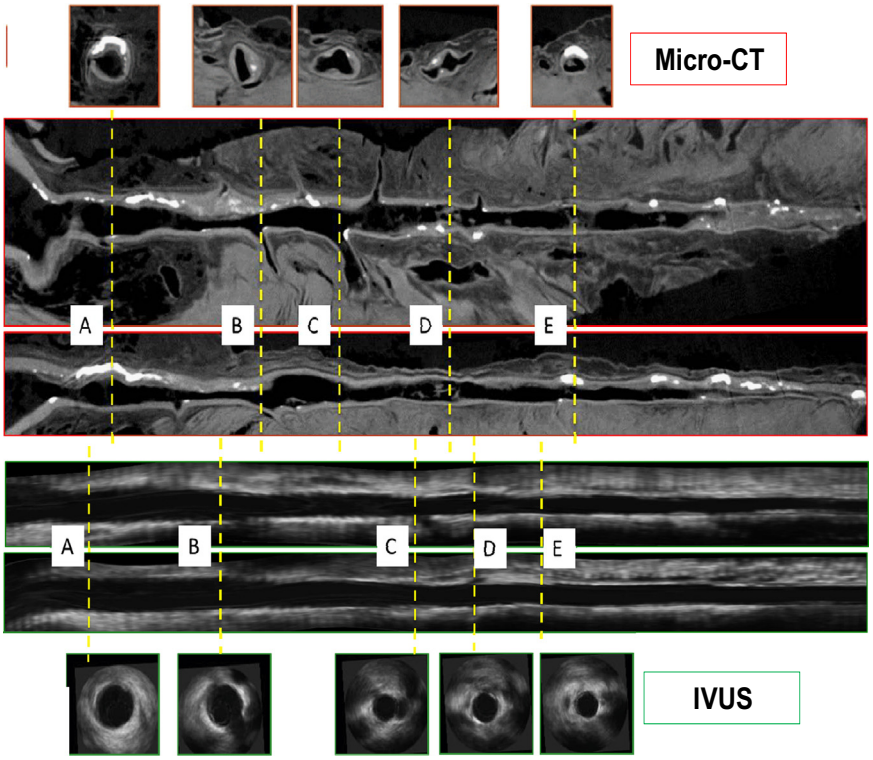

Fig. 2. Micro-CT and IVUS registration. Five different landmarks were identified on both IVUS and micro-CT cross sections, by the experts. Bifurcations were detected on B, C, Bifurcations and Calcium were detected on D, E and Calcium was detected on A.

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