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Automatic labeling of coronary arteries in computed tomography angiography images

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Abstract— **The objectives of this study were to develop an automatic algorithm for labeling coronary arteries in coronary computed tomography angiography (CCTA) images and to examine the reliabilities of this method. In total, 157 patients who underwent CCTA scanning were retrospectively included. An automatic coronary artery labeling algorithm based on the distance transformation algorithm is proposed to identify the anatomical segments of the centerlines extracted from CCTA images. Sixteen segments were identified and labeled. The results obtained via the algorithm were recorded and reviewed by three experts. The performance of segment detection and labeling of each segment was evaluated, and the proportion of agreement between the two experts on the manually labeled segments was also calculated. Compared with the labels of the experts, 117 labels (5.37%) (2180 segments) from the algorithm needed to be changed or removed. The overall accuracy of label presence was 96.21%. The average overlap between the expert reference and algorithm labels was 94.03%. The average agreement between the two experts was 94.98%. An automatic labeling algorithm was proposed, and a preliminary evaluation showed a high accuracy of the algorithm labels with respect to the labels from the clinical experts. This method is promising for labeling coronary arteries automatically and alleviating the workload of radiologists in the near future.**

Clinical Relevance— **The automatic labeling algorithm established with the distance to the LA and LV can help improve the segment detection and labeling accuracy for CT imaging. The proposed algorithm can accelerate the report generation process and provide bases for diagnosis.**

I. INTRODUCTION

Coronary computed tomography angiography (CCTA) is widely used for the diagnosis of cardiovascular disease. In clinical practice, it requires radiologists and cardiologists to manually complete the reconstruction process based on 2-dimensional transaxial images before writing the radiology report. According to the Society of Cardiovascular Computed Tomography imaging guidelines, radiologists and cardiologists need to report pathological findings per artery or per segment based on this reconstruction, which is a time-consuming process. Therefore, an accurate automatic labeling algorithm is essential since the labeling of coronary arteries is the basis for the diagnosis. The published results of the labeling techniques on CCTA varied, with the overall accuracy ranging from 85 to 92%. And, the accuracy for the left circumflex artery (LCx) was relatively low because the large vascular variation in the LCx[1-2]. Therefore, a method for accurate automated vessel tree labeling would enable the labeling of main arteries and side branches, such as the LCx and the first and second obtuse marginal branches (OM1 and OM2). The objectives of this paper are 1) to propose an efficient automatic labeling algorithm for coronary anatomy using a distance transformation algorithm; 2) to evaluate the automatic identification results by means of experts.

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II. METHODS

This study included retrospectively collected CCTA scans of 157 patients who underwent standardized CCTA. According to the processing pipeline, our research can be divided into several successive steps: 1) centerline extraction from the segmented coronary arteries; 2) myocardium structure and 3D volume data extraction; and 3) artery branch labeling based on the distance to the myocardium.

III. RESULTS

The overall accuracy for label presence was 96.21%. The pCx and LCx had high accuracy (98.73% and 92.99%, respectively). By averaging the overlap differences between the experts, the average overlap accuracy on 16-segment labeling is 94.03%. The percentages of agreement on the labels of the pRCA, mRCA, dRCA, R-PDA, LM, pLAD, mLAD, dLAD, pCx, and LCx were 100%, 100%, 100%, 98.09%, 100%, 99.36%, 99.36%, 98.09% and 94.27%, respectively.

IV. DISCUSSION & CONCLUSION

The proposed labeling algorithm can label coronary arteries on CCTA image with a high accuracy and in a fully automatic manner. Generally, the algorithm made good use of both upstream and downstream contextual information and generated results that were more robust than those of other methods. Moreover, it can be used in both pathological and healthy data without the need for a training database. The proposed method for automatic labeling of coronary arteries will reduce the labor of radiologists in the near future.

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