

## A Review on the Characterization of Coronary Arteries 3D Motion

Lung cancer accounts for the highest incidence and mortality rates among all kinds of cancer worldwide [1]. Thus, precision treatment for lung cancer is in significant demand. Radiation therapy (RT) has become one of the main treatment for lung cancer second only to surgery. To implement high precision radiation therapy, image guided radiation therapy (IGRT) was commonly used [2]. In the process of radiation therapy for pulmonary tumor, coronary artery is one of the most vulnerable tissue. Once exposed to radiation beyond normal dose, radiation heart diseases can be caused. Quantitative description of coronary artery motion can be used for planning circumvent strategy and also for diagnosing and treating cardiovascular disease (CVD).

The motion of coronary artery is effected by both heart beating and respiration. And its movement and deformation are heterogeneous during a cardiac cycle [3]. In early works, X-Ray angiography is the main technique for visualizing the motion of the coronary arteries. And coronary motion is tracked in 2-D projection images, which is limited by the overlap of vessels [4]. In order to recover the 3-D motion information of coronary artery, the 3-D coronary tree is reconstructed for each cardiac phase in [4][5][6]. These days, due to the advance in 3-D echography, cine-MRI, and multislice computed tomography (MSCT), the 3-D CTA is available for describing the motion of full cardiac structures [8].

Few works have been devoted to the characterization of coronary artery motion. A detailed discussion on the global and local coronary artery motion features was given in [7]. The displacement and 3-D velocity of the landmarks were analyzed in [8] from MSCT angiography. A template matching method was used in modeling coronary artery motion in [9]. While in those works, coronary centerline extraction was carried out repeatedly for each phase in a cardiac cycle. The correlation between adjacent phase has not been employed to improve the effectiveness of the extraction method.

Accurate extraction of coronary centerlines is an important step for assessing the motion of coronary artery. Numerous methods has been presented for extracting coronary centerlines for 3-D CTA. Early reviews of 3-D vessel segmentation techniques can be found in [10][11]. In recent works, a machine learning-based framework for vessel segmentation [12] has outperformed the widely-used hessian-based vesselness [13] and optimally oriented flux (OOF) [14]. A graph-based method using tubularity Markov tree (TMT) was proposed in [20]. This method is proved to be more accurate and time efficient than some classical graph-based methods. For challenging image quality conditions, a generic curvature based vessel segmentation method [21] was proposed to segment the vessels by minimizing surface curvature. Example-based segmentation and component-tree were used in the extracting cerebral vascular networks [22], which has taken the advantage of expertise of the clinician to avoid possible errors. However, when the temporal dimension is added, selecting a few seed points manually for each frames could be a rather laborious task for semi-automatic extraction. Besides, the image quality of 3-D CTA sequence could be unstable due to the presence of different levels of movement artifacts. A robust and efficient vessel segmentation method dedicated to 3D+t CTA.

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