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Blood Simulations in an Arterial Model Automatically Reconstructed Using Optical Computed Tomography

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Extended Abstract

Optical Coherence Tomography (OCT) has proven to be a superior imaging modality for the assessment of coronary artery disease, offering high-resolution visualization of vascular structures. To enhance the accuracy of blood flow simulations within vessels, X-ray images are integrated to reconstruct patient-specific 3D vascular models that incorporate curvature and anatomical details. To construct patient-specific 3D vascular models, OCT images were first divided into individual frames and converted into separate images. These raw OCT images served as input data, while a thresholding process was applied to distinguish the intraluminal region from the vessel wall. This processed dataset was then used to train a machine learning model based on the ResNet50 architecture for automated vessel extraction. The machine learning-based approach is employed to accurately extract the lumen from OCT images, facilitating the reconstruction of a precise 3D vascular geometry. The vessel-length based physiological lumped modeling was couple with 3D computational fluid dynamics simulation. Haemodynamic simulations, based on the continuity equation and Navier-Stokes equations, are then performed to compute key physiological parameters, including non-invasive fractional flow reserve (FFR), velocity distribution, flow streamlines, and wall shear stress. We compared the computed non-invasive FFR with clinically measured FFR values to validate the accuracy of our approach. The accuracy, sensitivity, specificity and area under ROC curve to evaluate the diagnositic performance of computed FFR. These computed metrics provide valuable insights into vascular hemodynamics and aid in identifying regions prone to ischemia. The integration of OCT-based FFR with computational fluid dynamics enhances the non-invasive assessment of coronary artery disease, ultimately contributing to improved diagnosis, risk stratification, and treatment planning for vascular disorders.

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