COMPREHENSIVE EVALUATION OF A PSEUDO-SPECTRAL METHOD FOR WALL SHEAR STRESS ESTIMATION IN CARDIOVASCULAR FLOWS UNDER VARYING CONDITIONS

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Abstract. Wall Shear Stress (WSS) is a critical quantity that influences the development and progression of cardiovascular diseases, particularly atherosclerosis. Understanding the relationship between WSS and disease progression is essential for improving risk assessment, diagnosis, and treatment strategies for these diseases. This calls for an accurate WSS quantification based on available data [1, 2] This paper focuses on the validation of a previously introduced Pseudo-Spectral Method for WSS quantification from 2D ultrasound vector Doppler measurements, aiming to assess its performance under various conditions following a comprehensive validation approach. The validation process begins with an initial assessment using laboratory data in a stenotic case [3], demonstrating its accuracy under controlled conditions. Subsequently, the method's performance is rigorously tested through Computational Fluid Dynamics (CFD) simulations. Three crucial aspects are systematically studied in these simulations: diameter stenosis, stenosis length, and curvature. Recognizing the challenges posed by real-world data, the study also assesses the method's robustness by introducing varying levels of noise into the data, simulating real data scenarios. The findings of this study provide valuable insights into the performance of the Pseudo-Spectral Method for WSS estimation in cardiovascular flows. The pseudo-spectral method seems versatile in accommodating different configurations and robustness in handling noisy data. This highlights its potential as a valuable tool for clinicians and, possibly, device manufacturers.

Keywords: Wall Shear Stress, Doppler imaging, Interpolation, Pseudo-spectral differentiation, Numerical differentiation, Computational Fluid Dynamics

Mathematics Subject Classifications (2010): 76D05, 65Z05, 76M22

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