An efficient multiscale model to simulate the motion of particulate matter in the human airways

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Abstract

Particulate Matter (PM) emanating from burning of fossil fuels, and traffic emission, have negative implications on the health and well-being of the human being. The inhalation and transportation of PM can be deposited in the human lung, thereby contributing to a high risk of pulmonary disease. Computational fluid dynamics (CFD) simulations have been used to predict the deposition of PM in the human respiratory tract for a number of years. With the advancements of computed tomography (CT) and magnetic resonance imaging (MRI) technology, the realistic lung model becomes more popular for scientists and researchers. However, due to the complexity of the human airway, achieving high level of numerical accuracy and efficiency is still a big challenge. Even with the help of high performance computing (HPC), modeling particle-fluid simulations in the realistic CT-scan based lung model takes weeks or months. The objective of this research is to develop a multiscale model to improve the computational efficiency of particle-fluid simulations in the human lung system. A multi-level method is proposed to decompose the airways into different levels. In addition, a multi-grid approach based on the radial point interpolation method (RPIM) and averaging method is developed to couple different levels. ANSYS FLUENT is used for the implementation of the proposed multiscale method. The feasibility of the method is verified, and the accuracy as well as the efficiency of the multiscale model are investigated.

Keywords: Computational Fluid Dynamics, Multiscale Modelling, Radial Point Interpolation Method, Particle-Fluid simulation, Human Airways