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An efficient Computational Fluid-Particle Dynamics method to predict deposition in a simplified approximation of the deep lung

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Abstract

High-fidelity simulations of the complete airway tree are still largely beyond current computational capabilities. Towards large-scale simulations of the human lung, the current study introduces a numerical methodology to predict particle deposition in a simplified approximation of the deep lung during a full breathing cycle. The geometrical model employed consists of an idealised bronchial tree that represents generations 10 to 19 of the conducting zone and an heterogeneous acinar model created using a space-filling algorithm. The computational cost of the coupled simulation is reduced by taking advantage of the flow similarity across the central conducting regions in order to decompose the bronchial tree into representative subunits. Topological information is used to account for the correct gravitational force on the particles in the representative bifurcations, emulating their transport characteristics in the actual bronchial tree. Eventually, airflow and particle transport are simulated in a single representative bifurcation and a single acinar model, resulting in great savings in computational cost.

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