Nonrigid Image Registration and its Applications for Subject-specific Lung CFD Simulations

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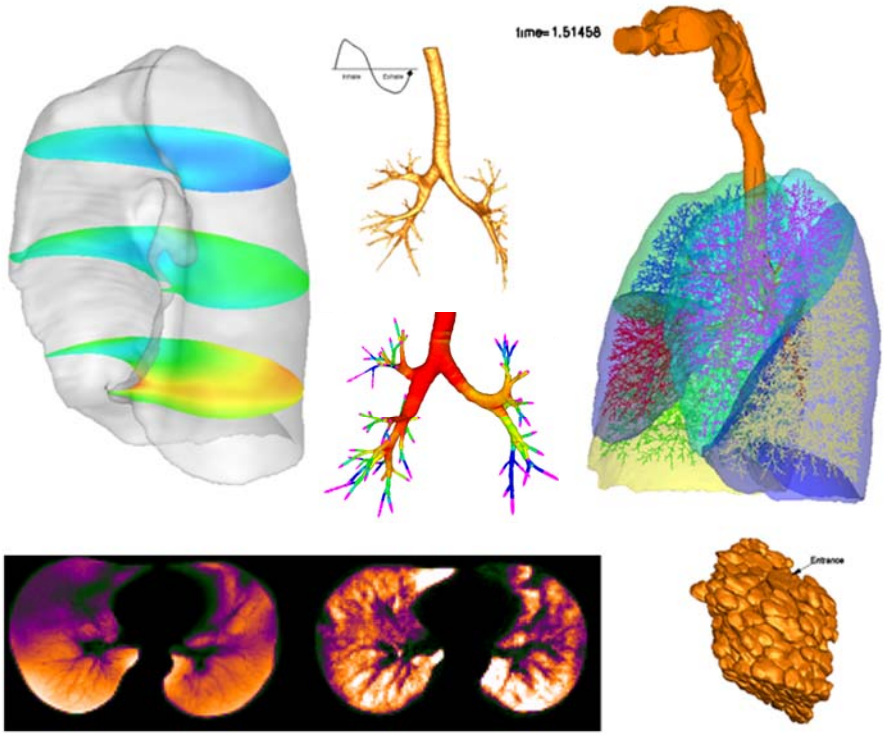

Computational fluid dynamics (CFD) has become an attractive tool in understanding the characteristic of air flow in the human lungs. Due to inter-subject variations, subject-specific simulations are essential for understanding structure-function relationship, assessing lung function and improving drug delivery. However, currently the subject-specific CFD analysis remains challenging due, in large part to, two issues: construction of realistic deforming airway geometry and imposition of physiological boundary conditions. This presentation will first describe a mass-preserving nonrigid registration algorithm for matching three-dimensional (3D) MDCT lung images. We further demonstrate the ability to develop realistic, subject-specific dynamic lung models by utilizing the proposed registration method in order to address these two issues above. The proposed lung model combines both the 3D and 1D airway trees, considers the regional ventilation from a local voxel to global sub-lung regions, and accounts for turbulent-transitional-laminar flows, thus accounting for the nature of the multiscale in pulmonary air flow. Additionally, we developed image processing pipelines to evaluate CT repeatability, link MDCT-MRI lung images, build micro-CT-based acinar models, and study lobar sliding and FEM-based lung mechanics.