Integrated multi-scale simulation of pulmonary respiration – from nasal cavity to alveoli

Dr Toshihiro Sera (Osaka University) & Prof Robert Schroter (Imperial College)

Departments and institutions involved within Japan:

The Center of Advanced Medical Engineering and Informatics, Osaka Univ.
Graduate School of Engineering Science, Osaka Univ.
Department of Mechanical Engineering, Chiva Univ.
Research Center for Simulation Science, Japan Advanced Institute of Science and Technology

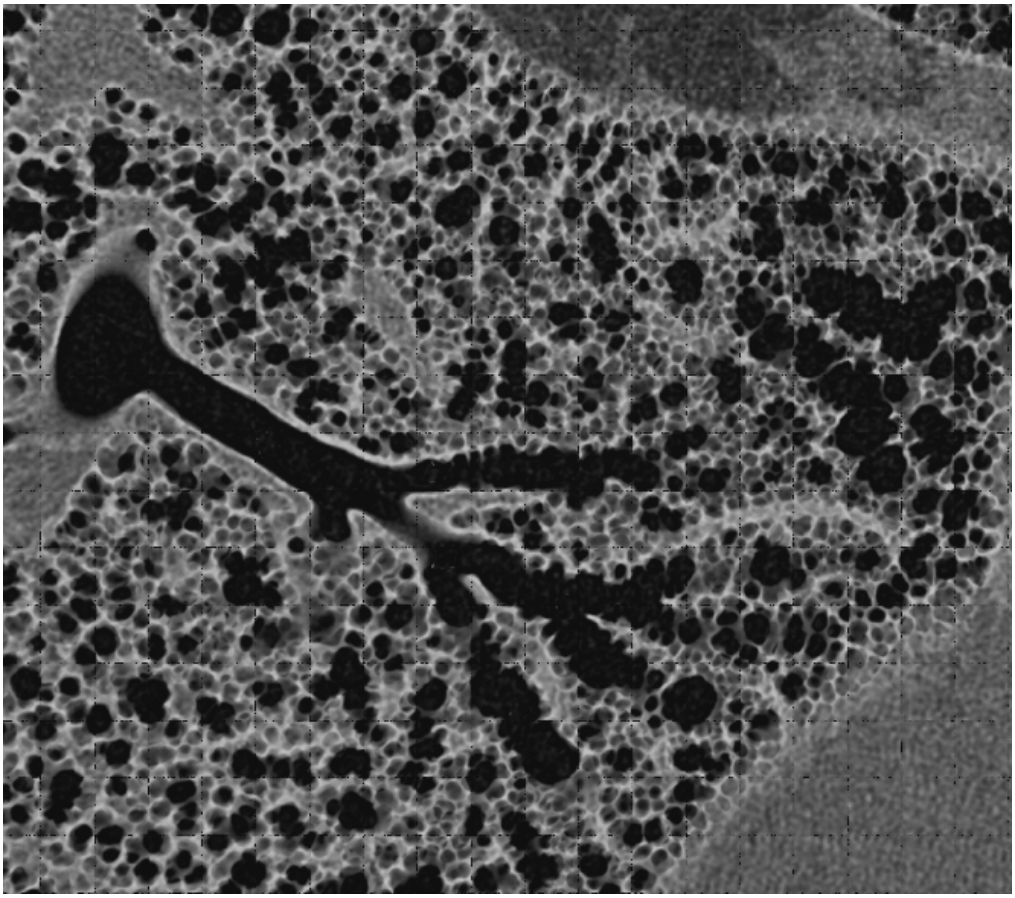
UK Institution:
Imperial College London
Department of Bioengineering and Department of Aeronautics

In association with the Imperial group, the Japanese collaborating team has established an extensive, unique database of digital anatomical data on the respiratory tract of a range of mammalian species, most strongly focused on human clinical CT images of the nose and major respiratory tract structures and extremely high structural resolution synchrotron images (cubic voxels of 2.8μm; 4000 x 4000 x 134 pixels) of pulmonary parenchyma, particularly alveolar arrangements, in small mammals. These are obtained in life or near physiological conditions. The parenchymal data provide unique insight deep within the lung, into both the short and long range 3D structural organization and relative movements during inflation. Additionally, the Japanese team has developed a mesh free computational fluid dynamics (CFD) solver and to evaluate detailed dynamics of flow conditions in the nose based on CT imagery.

The Imperial College group has long established physiological and biomechanics expertise relating to the lung. It has unique expertise in modelling lung geometries based on image processing and CFD and other computational methods relating to airflow dynamics, transport and deposition in the respiratory tract. Relating this expertise to that being developed with the Japanese groups is providing a unique ability to investigate real time dynamics of processes in integrated multi-scale simulations of respiratory function from nose to alveolus.

The JSPS funded international collaboration has provided an invaluable basis for future long term collaboration between our groups and a stimulus for other related research centres within our respective countries to join our consortium. Further application to JSPS and elsewhere is planned to continue bidirectional international visits and fund young investigators to undertake the related data gathering and modelling in both the UK and Japan.

All grant income (approx £17,500 pa) was expended by the Japanese participants on research within Japan and travel costs to UK for collaboration discussions. UK research expenses were derived from relevant grants on related work, or individuals' personal research funds.



Representative volume-rendered micro-CT image. A conducting airway, bronchiole, alveolar duct and individual alveolar openings are visualized clearly. Light gray areas are of lung soft tissue without, such as a pulmonary vessel, airway wall or interstitium.