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An automated reconstruction of the lungs for CFD simulations

*** Julien Pennecot[1] and Lars Krenkel[2]**

[1] DLR, AS-FS
Bunsenstr, 10
37073 Göttingen, Germany
julien.pennecot@dlr.de

[2] DLR, AS-FS
Bunsenstr, 10
37073 Göttingen, Germany
lars.krenkel@dlr.de

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ABSTRACT

Most of the patients admitted in the intensive care unit need artificial ventilation. A better comprehension of the processes involved in air transport within the lungs is necessary in order to optimize the artificial ventilation techniques. Nowadays, CFD allows to simulate the flow within the lungs. Nevertheless, a CFD mesh is required as an input by CFD simulation softwares. The mesh generation is normally long and cumbersome with a lot of manual interventions. In this paper, we present a set of tools allowing to quickly generate a CFD mesh of the lungs based on a set of CT images. The entire mesh generation has been automatized. In our case the developed mesh generation technique has been applied to a CT dataset of an isolated pork lung.

The image processing was performed on all images simultaneuously using techniques such as thresholding, blurring and edge detection. Then, an advancing front method has been used to obtain a single

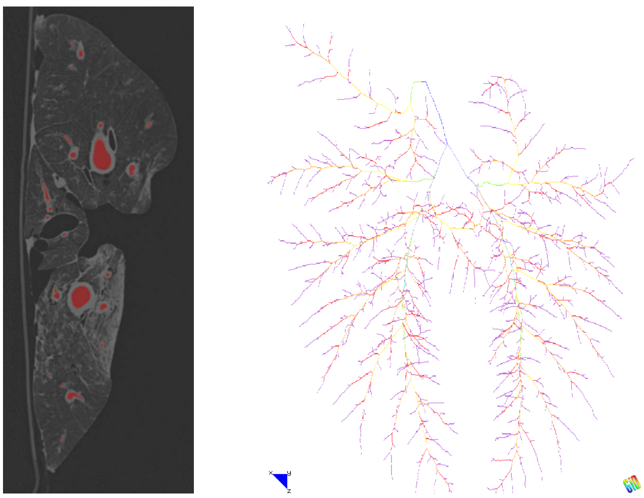

Figure 1: During the image processing the bronchial tree (red) is isolated (Left). The skeleton of the lung is extracted. It allows to determine the generation of each branch (color coded) (Right).

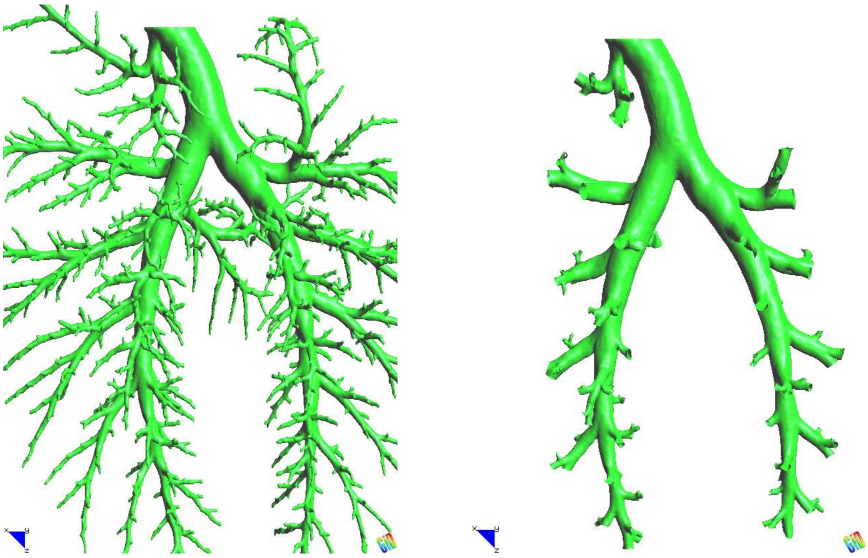

Figure 2: Surface mesh including all generations (Left), Final surface mesh with 4 generation of branches (Right).

set of connected voxels. It allowed to capture the entire bronchial tree and to differentiate it from the pulmonary blood vessels (Figure 1).

The skeleton of the bronchial tree (Figure 1) is extracted from the stack of images using an algorithm based on two distance fields. The position and direction as well as the generation of all branches is retrieved from the skeleton. This step allowed at a later stage to cut the surface mesh at a specified generation.

The surface mesh is generated using a marching cube method, a non shrinking smoothing and a polygon reduction algorithm. The full bronchial tree as delivered by the image processing is meshed with triangles (Figure 2). The branch ends are then cut using the information delivered by the skeleton. The user can choose how many generations of branches the lung model should have (Figure 2). Outlet markers are set at the branches ends. The volume meshes can then be created with a standard unstructured tetrahedral mesher.

This process allows the user to build automatically from a stack of medical images a good CFD mesh ready for simulations. Meshes with four to eight generations of branches can be quickly generated. This process allows to reduce the time used during mesh generation and therefore to concentrate more on the simulation. This technique could also be implemented for blood vessels.

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