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CFD Mesh of the Human Nose and Flow simulation

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ABSTRACT

The complexity of the human nose can be explained by its many purposes. It warms and humidifies inspired air and filters out small airborne particles before air reaches the lungs. The nasal cavity and the sinuses are also used in the olfaction process by trapping odor-bearing particles in a mucous substance that coats the walls.

But interactions of these effects are not fully understood. The nasal airways should therefore be studied as a whole. Fortunately, due to the tremendous improvements in computer science during the last decade, it is now possible to perform CFD simulations for extremely complex geometries.

In most of the studies available in the literature, the geometry of the patient nose as been either idealized or simplified; i.e. only the meati are modeled and the sinuses are ignored. This simplification process can be long and cumbersome or worse can lead to errors if the simplification used is too strong. Although the sinuses do not significantly affect the flow, they have been considered in the presented work to test

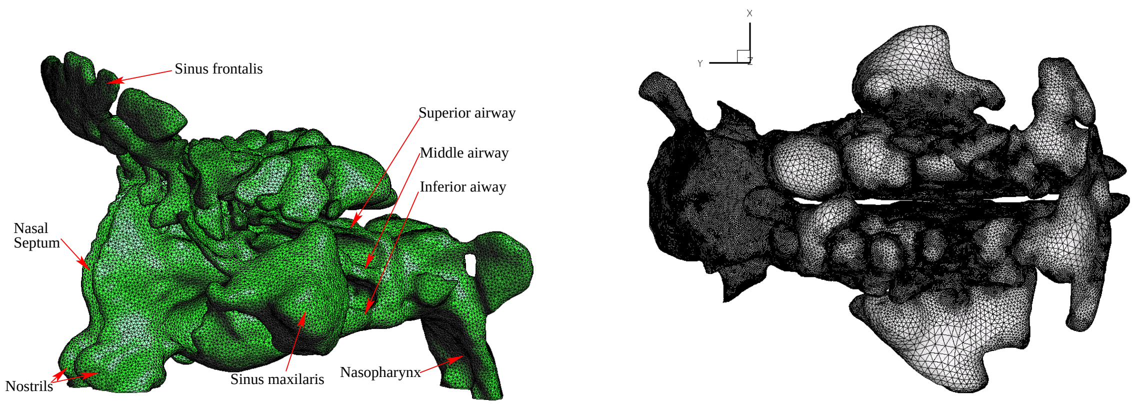

Figure 1: Surface mesh (Left), Volume mesh using density sources(Right)

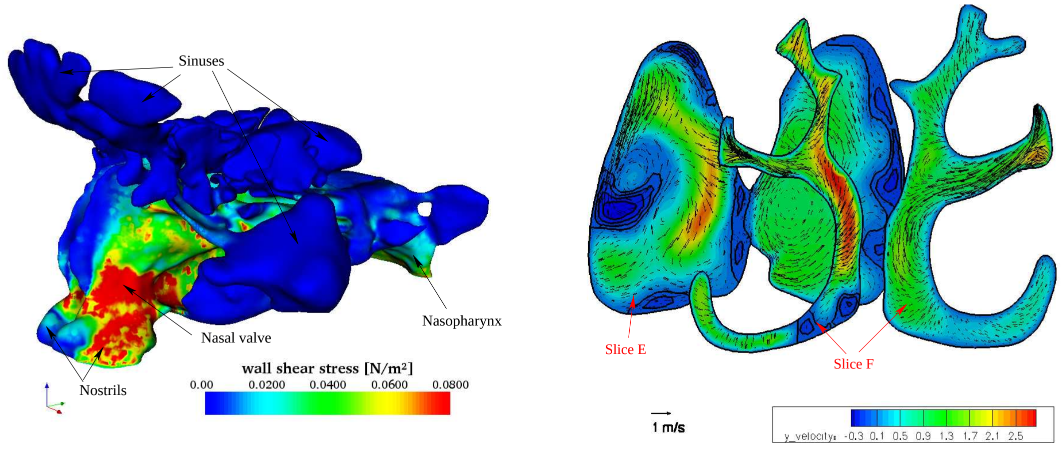

Figure 2: Magnitude of the wall shear stress on the nose. Its maximum can be observed in the proximity of the nasal valve. (Left), Two significative slices of the nasal cavity. The “in plane” velocity has been represented by vector while the “normal velocity” has been represented by colors scale. For negative values of the normal velocity (recirculation zones) isolines have been plotted.(Right)

the reconstruction algorithm on a highly complicated geometry and in order to try to understand the effects of the sinuses in the respiration process.

In this study, we used a set of tools in order to quickly create a high fidelity CFD mesh of the complete nasal cavity based on a set of CT images. The created mesh is then used for a numerical simulation. The aim is to use this method in the future to visualize the flow in the nose of a patient, and possibly to guide the physicians in how the breathing capabilities of a patient can be improved.

The following techniques have been used in order to obtain the surface mesh: blurring, edge detection, thresholding, advancing front and marching cube method, non-shrinking smoothing and polygon reduction methods. The grid generator NETGEN was applied to the surface mesh to generate the final tetrahedral volume CFD mesh. Special care has been taken in order to add density sources during the volume mesh generation. It allowed to increase the number of cells in the grid zones where high velocities were expected. The mesh obtained includes all sinuses (Figure 1).

CFD simulations using the DLR code THETA were carried out for the inspiration phase for a patient at rest. These simulations provided the following informations about the patient: Pressure loss and temperature difference between the nostrils and the nasopharynx, mass flow rate, which could be compared to experimental data. The simulation also allowed to visualize the local phenomena such as the wall shear stress or the local recirculation zone close to the nasopharynx (Figure 2)

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