# CLASSIFICATION OF NASAL PATHOLOGIES: ENHANCING MACHINE LEARNING WITH COMPUTATIONAL FLUID DYNAMICS

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A wide category of flow problems exists that can be posed in terms of an optimization, whose objective is clear but not readily available as a function of the problem variables. In such cases, data driven approaches shine into connecting different types of data such as a velocity field (i.e. array of floats) to a label (i.e. a string) without the need of an explicit connection in mathematical terms.
The application we are interested in is the classification of geometries starting from information related to the flow field. In particular, we address in this work a well defined application scenario: the classification of anatomical deformations of the human nose. Their classification would be key to provide the Ear Nose and Throat (ENT) surgeon with precious information for surgery planning. Instead of training a classifier based on (a huge number of) annotated CT scans, in this work we apply a standard ML pipeline of feature extraction, feature selection and classification where the input features are CFD-based and derived form the flow field. Since CFD plays a crucial role in the understanding of nasal pathologies and provides functional information that is unavailable from visual examination of the CT scan, the rationale for this study is that CFD-based features might enable good performance for classifiers trained on small datasets, which is the standard for medical ones, in which the number of labeled observations is bound to remain limited.
How to arrive at a RANS/LES/DNS solution of the nose flow starting from a CT scan is well known [1, 2]. Figure 1 shows a segmented CT scan and the corresponding reconstructed three-dimensional surface.
One peculiar feature of the present study lies with the anatomies. Starting from 7 healthy patients, and taking advantage of functional mapping [3], a technique derived from computation geometry, we create the dataset by injecting specific pathologies (alone or in arbitrary combinations) to each of the baseline anatomies, and by carrying out highly resolved LES for each of them. The current dataset includes around 300 LES. Informative fluid dynamic features are then extracted and used to train a neural network and to classify the pathologies. The pathology tree and the two classification experiments are depicted in figure 2.
The neural network is then tested with different partition strategies, including the leave-one-out method, which is the most reasonable for this use case in which the NN is expected to be used on a case that was unavailable beforehand. Results are positive and encouraging, and confirm that highly informative fluid dynamic features can be used as input of a ML pipeline to classify geometries. This is a useful characteristic whenever pipeline in situations that lack high number of annotated data.
At the conference, we will explain why flow-based features can outperform geometrical features, as the simple one depicted in figure 3, i.e. the evolution of the cross-sectional area of the passageways. We will also show that the performance of the network can be further improved by enlarging the number of observations.

## References

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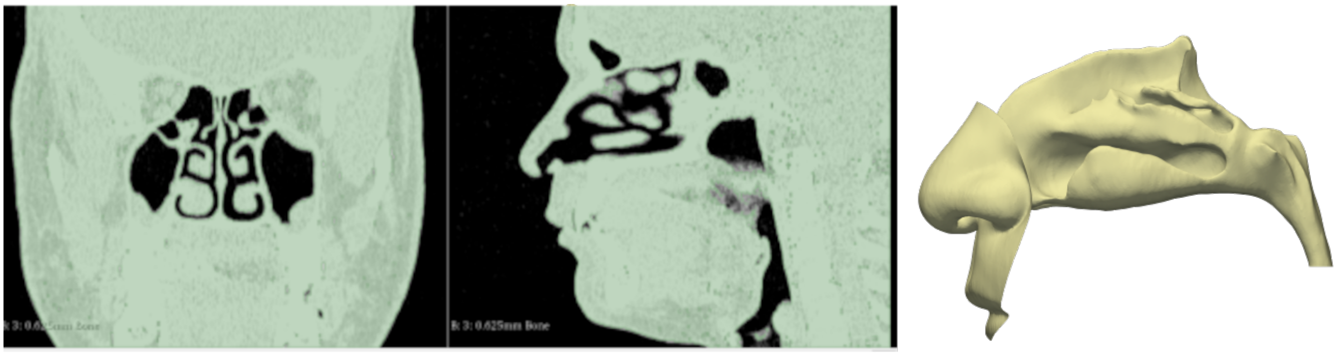

**Figure 1: Nasal anatomy: from the CT scan (left) to an STL after removal of the sinuses (right).**

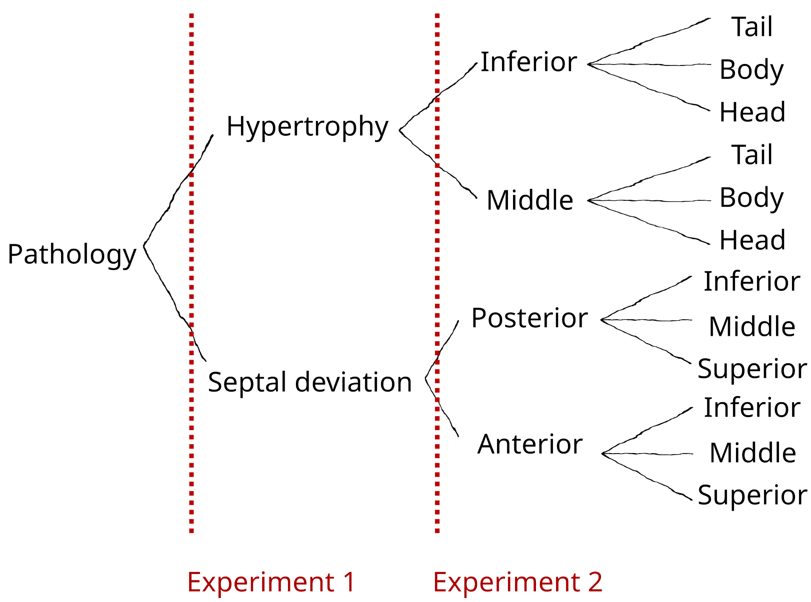


**Figure 2: Tree of deformations, with the classification experiments described in this work.**

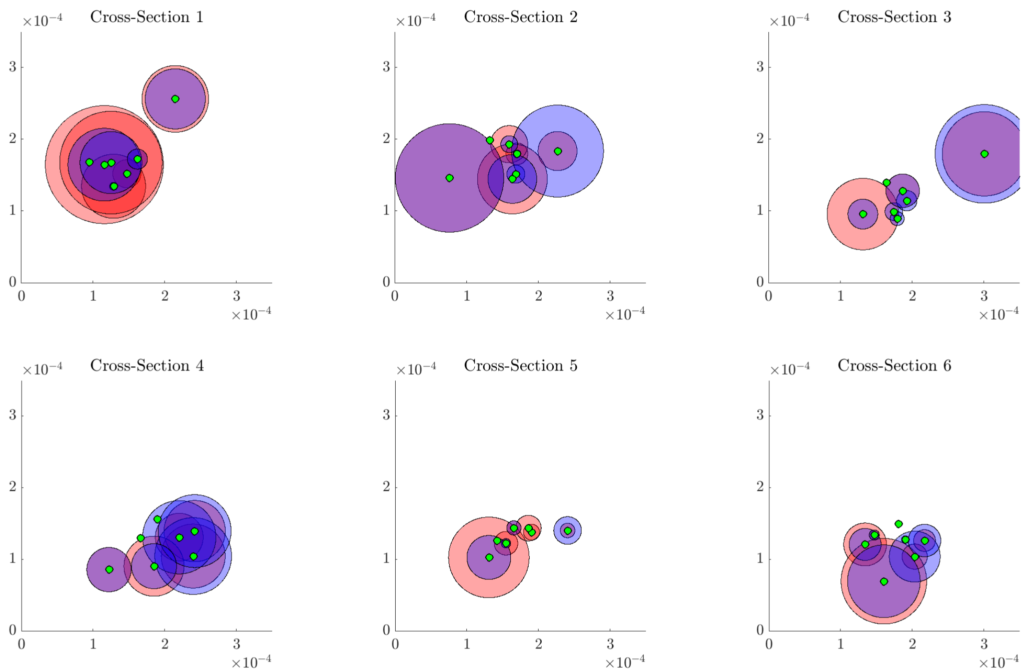


**Figure 3: Cross sectional area in the two meati (right on the horizonal axis, left on the vertical axis) for the healthy cases (green dots). Circles represent the average area change for the set of pathologies derived from each patient. Blue: hypertrophy; red: septal deviation.**