A CFD-augmented machine-learning approach for the classification of nasal pathologies

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Computational fluid dynamics (CFD) provides global properties of the flow solution (e.g. drag of a body) which can be used in an optimization process to minimize a cost function (e.g. power loss in a system). However, problems exist where a CFD-accessible cost function is not easily available or is not known as a function of the fluid variables. One such case is the medical diagnosis of conditions involving fluid flow; the information ultimately relevant to the doctor is not the CFD field itself, but where and whether or not to perform the surgery.

This work focuses specifically on the diagnosis of Nasal Breathing Difficulties (NBD). Ear, nose and throat surgeons use a variety of surgical manoeuvres, but often consensus is lacking on the best surgical approach for a specific patient. In fact, after surgery, patients often report unimproved NBD symptoms[1]. In such scenario, the CFD analysis is important insofar as it provides functional information[2] not available through a simple CT-scan (Fig. 1a). CFD information can then be integrated into a Machine-Learning (ML) pipeline to classify nasal pathologies.

In this work, we present a dataset of more than 270 LES of 7 different patients carrying a combination of 17 pathologies: 8 turbinate hypertrophies and 9 septal deviations. Flow features extracted from the dataset are used to train a neural network binary classifier which distinguishes between septum and turbinate pathologies. Seven classifiers are trained, using only 6 patients at a time, the remaining one serving for testing only. Preliminary results are shown in Fig. 1b. The success of the classification task shows that augmenting a common ML pipeline with CFD features enables the prediction of functional properties of complex fluid dynamic systems.

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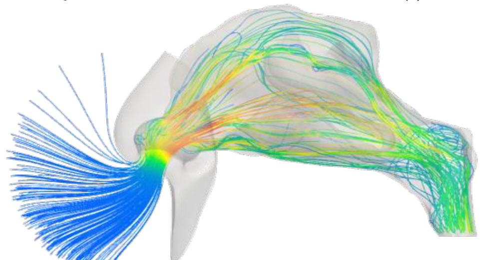
[1] Sundh and Sunnergren, *Eur Arch Oto-Rhino-L*, 272(10), 2871-2875, (2015).

[2] Quadrio et al. *Eur Arch Oto-Rhino-L*, 271(9), 2349-2354, (2014).



(a)

Tested patient	Training + Val Dataset size	Classification accuracy
1	257	80%
2	238	71%
3	233	82%
4	225	93%
5	233	95%
6	219	71%
7	227	89%

(b)

Figure 1: (a) LES-computed mean flow in a patient-specific nasal cavity. The flow is visualized by mean streamlines, with colour indicating local velocity's magnitude. (b) Result of binary classification: training on 6 patients and test on the 7th one.