

# Supervisor Expression of Interest

## MSCA - Marie Sklodowska Curie Action - (PF)

### Postdoctoral Fellowship 2025

**Supervisor name:** Maurizio Quadrio

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**Link "Pagina docente":**

**Department Name:** Department of Aerospace Science and Technologies

**Research topic:** Fluid Mechanics of the Human Nose

**MSCA-PF Research Area Panels:**

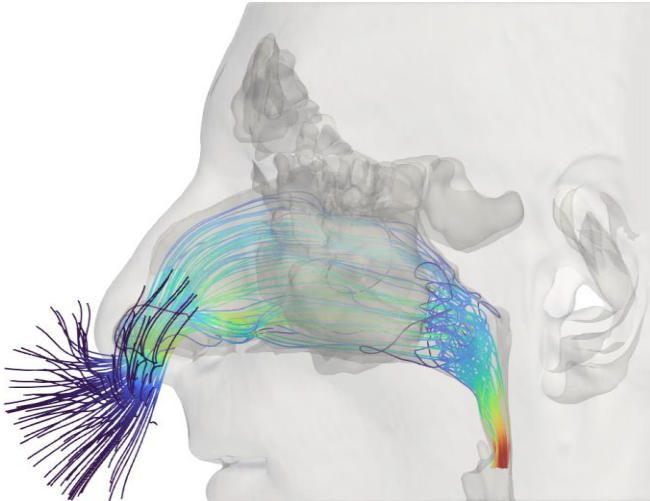
- ENG\_Information Science and Engineering

**Brief description of the Department and Research Group (including URL if applicable):**

The Department of Aerospace Science and Technologies is the only academic department in Italy devoted to aerospace, with 70 faculties and over 200 doctoral and postdoctoral students. Advanced experimental and numerical methods are also applied in fields where being at the forefront is essential. One such field is respiratory fluid mechanics: prof. Maurizio Quadrio has started and is leading the international OpenNOSE workgroup for the clinically-driven research in fluid mechanics of the human nose, and is also involved in ground-breaking high-fidelity simulations of the lungs flow.

## Designing nose surgeries with machine learning and fluid mechanics

The human nose humidifies, filters, warms and senses what we breathe, and plays a crucial role in our well-being. Its anatomy and physiology are complex, and many aspects remain unknown. Nasal breathing difficulties are astoundingly high in incidence, affecting one third of the world's population, and often require surgical corrections. Their total cost is huge, with an extrapolated worldwide figure of the order of trillions of euros per year. Surgeries very often do not relieve the symptoms, with e.g. septoplasties (straightening of a bent nasal septum) incurring in up to 80% failure rate.



This poor state of affairs is due to the lack of functional (i.e. fluid mechanical) information available to the medical doctors: diagnosis is mostly based on anatomy information, derived from a maxillo-facial CT scan. The impressive anatomic variability among healthy noses, together with the strong non-linearity of the problem, is such that a functional reference is lacking: how a normal nose works remains unknown to a large extent, and to date a clear guidance on how to restore the correct function via surgery is not available.

In this work, we develop a novel approach to understanding, diagnosing and treating nasal breathing difficulties. An original computational model, tailored to the nose flow and usable in a clinical setting, is used to feed a data-driven procedure that exploits fluid mechanics to extract the missing functional reference, i.e. the goal of a surgery. The functionally normal nose is an elusive notion that ENT doctors have failed to arrive at over the last centuries: the anatomically normal nose bears little relationship with the healthy nose. Therefore, we will resort to a data-driven approach to identify the functionally normal nose. Unfortunately, the conventional approach of training a neural network (NN) with a large number of images is not viable in this problem: the extreme anatomical variability of the nose translates into too large a training dataset, whose labeling become practically impossible. Moreover, labels (diagnostic indications) provided by ENT doctors are often non unique: a given CT scan typically contains several aspects peculiar to the patient, and different doctors may provide different labels. Therefore, we need to reduce the number of samples needed for training the NN, and to identify unequivocal labels.

To shrink the training dataset, the enabling idea is to use CFD-computed information for training. By training the NN via fluid mechanical features instead of geometrical features, we would tap information downstream of the non-linearity introduced by the equations of fluid mechanics, thus restoring the information content and making it conceivable to successfully train the NN network with hundreds or thousand of CT scans, instead of millions or billions. To find unequivocal labels, we give up the search for representative CT scans with nasal anatomies that are healthy but for one, well-defined anatomical defect, opting for manually introducing pathological variability in a controlled and parametrized way. In other words, pathological anatomies are not obtained from real CT scans, but created by injecting predetermined pathologies into healthy anatomies. The anatomical defects will be defined according to their surgical correction, such that that the classification will immediately translate into surgical advice.