

Doctoral recruitment 2020

- **Laboratory:** Synchrotron Radiation for Biomedicine (STROBE) Inserm UA07, University of Grenoble Alps; head Sam Bayat.
- **Title:** Regional pulmonary function measured by automated analysis of CT images for predictive phenotyping in COPD.
- **Supervisor:** [Sam BAYAT](#), MD PhD, laboratory STROBE Inserm UA07, Grenoble
- **Co-supervisor:** [Maciej ORKISZ](#) PhD, laboratory [CREATIS](#), team MYRIAD, Lyon.
- **Keywords:** chronic obstructive pulmonary disease, computed tomography, image processing, image registration

Medical context

Chronic obstructive pulmonary disease (COPD) affects approximately 251 million people worldwide (3 million cases in France). The burden of this disease in terms of public health is a growing challenge in industrialised countries with the ageing of the population (1). It leads to exacerbations, a progressive decrease in respiratory function, and can lead to respiratory disability and death. Despite decades of research, treatments that can modify the course and mortality of this disease are lacking, partly due to limited routine knowledge of the patient's phenotype (1). Reduced lung function due to obstructive ventilatory disease is characterized by inhomogeneity of regional lung function. Recently, it has been shown that regional lung function data obtained by analysis of computed tomography (CT) images allows more accurate phenotypic characterization and personalized diagnosis, predictive of the course of the disease (2, 3).

Our hypothesis is that the phenotypic characterization of COPD patients based on a quantification of regional lung function by calibration of inspiratory and expiratory CT images is predictive of functional decline and the evolution and occurrence of clinical events such as exacerbations or hospitalizations.

Objectives and envisaged methodology

The objective of this project is to develop and validate image analysis tools for the rapid and reproducible measurement of regional lung function parameters from CT images at low doses of ionizing radiation in patients at risk or with COPD. Our approach (4) (Fig. 1) is based on segmentation followed by elastic registration of 3D inspiratory and expiratory images, automated and independent of operator intervention. It consists in quantifying regional lung deformation, but also regional ventilation and its heterogeneity based on the variation of local X-ray attenuation with respiration, as well as quantitative measurements of trapping and emphysema displayed in the form of a 3D map (2, 3).

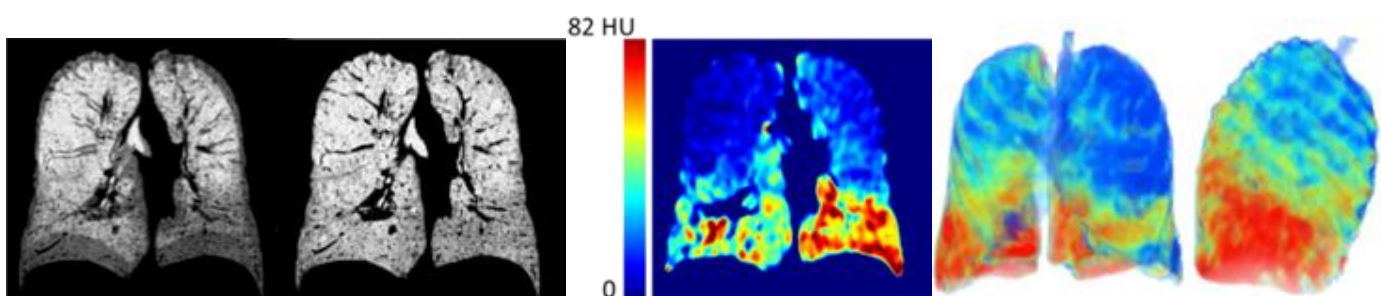


Figure 1 : Schéma de l'approche proposée : Segmentation → Recalage → Carte de Δ Densité → Ventilation Régionale

We have developed software for lung image registration, initially applied to experimental synchrotron X-ray tomography, in an animal model (5). We then adapted this software to the analysis of CT lung images in humans. Preliminary data obtained in a Grenoble cohort (ECOCOPD, monocentric, prospective, with a 3-year follow-up in 2019) of COPD patients demonstrate the feasibility of our approach for the calculation of regional pulmonary ventilation and its heterogeneity in these patients, whose pulmonary CT scans routinely include inspiratory and expiratory images. Our preliminary data show an association between regional ventilation and its heterogeneity and the occurrence of clinical events such as exacerbations of the disease within one year of imaging (4). These data suggest that functional, multiparametric analysis of pulmonary CT images appears to offer promising biomarkers for predictive phenotyping in these patients, opening up the possibility of early therapeutic interventions aimed at personalized treatment, even prevention of exacerbations and morbidity. However, current software has limitations in terms of computation time (~30 min) and quality of registration for large variations in expiratory-inspiratory lung volume. Therefore, in this thesis project a particular emphasis will be put on the implementation and validation of a fast and robust lung image registration algorithm in the presence of pathological changes. Applications in other pathological situations such as adult acute respiratory distress syndrome are possible, in order to accurately measure regional lung recruitability (6), a predictive parameter of evolution in these patients with acute respiratory failure under mechanical ventilation.

Financial support: LABEX PRIMES

Profile of the candidate (required skills): image processing, programming; skills in image registration and machine learning will be useful.

Skills that will be developed during the PhD: deepening of skills in image processing, machine learning and programming, acquisition and development of skills in modeling, simulation and dialogue with the medical community.

Application: Before the 15th of April 2020, send to the supervisors (M. Sam Bayat sbayat@chu-grenoble.fr and M. Maciej Orkisz maciej.orkisz@creatis.insa-lyon.fr) your resume and contacts of two references, preferably including your MSc project supervisor.

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