PhD proposal

Low-field 3D magnetic resonance spirometry for advanced regional exploration of respiratory diseases

Thesis start date	As soon as possible
Location	Université Paris-Saclay, BioMaps, SHFJ, Orsay 91400
	Siemens Healthineers, Courbevoie 92400
Key words	MRI, Lung, Function, Spirometry, Biomarkers, Deep diagnosis, Primodeficiency

1. V-LF-Spiro3D project summary

The aim of this project is to provide physicians with an original technique for assessing ventilation using magnetic resonance imaging (MRI) at any point in the lung: 3D magnetic resonance spirometry. This technique, recently developed at BioMaps, represents a paradigm shift in pulmonology, moving from the global to the local, and from forced breathing requiring the subject's cooperation to free spontaneous breathing. Currently being tested as part of the European V|LF-Spiro3D project in Germany, France, the Netherlands and the UK, it provides a very rich set of 3- and 4-dimensional parameters characterising respiratory function and mechanics at a local level (1 to 32 million measurements for each of these parameters).

2. PhD framework

Three-dimensional MR spirometry has recently been validated on 25 healthy subjects in supine and prone positions. The aim of this PhD work is to use a set of methods based on biomechanical modelling and deep learning to standardise 3D magnetic resonance spirometry and to turn it into a diagnostic tool at standard and low fields.

Firstly, the thesis will support the use of the technique at standard field (1.5 T and 3 T) to acquire a 3D MR spirometry database and to establish nominal atlases of biomarkers and criteria of the functional and dysfunctional state of the lung in healthy volunteers, asthma patients, COPD patients and lung transplant patients (240 adults, 30 children). The atlases of the different populations will then be modelled using poroelastic simulations carried out by the INRIA M3DISIM team in order to reduce the parameter space and reveal the determinants of the diseases. A deep learning diagnostic approach will then be developed for all the acquired data sets,

to integrate 3D MR spirometry into clinical research and routine care. Finally, this approach will be transposed and opened up to low field strengths (0.55 T Siemens Magnetom FreeMax) to compensate

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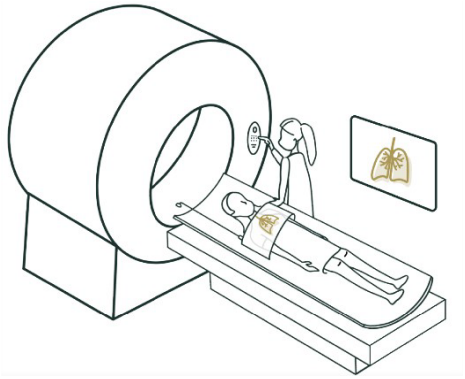
for the lower signal-to-noise ratio and to benefit from the exceptional contrasts obtained in the lungs at these magnetic field strengths.

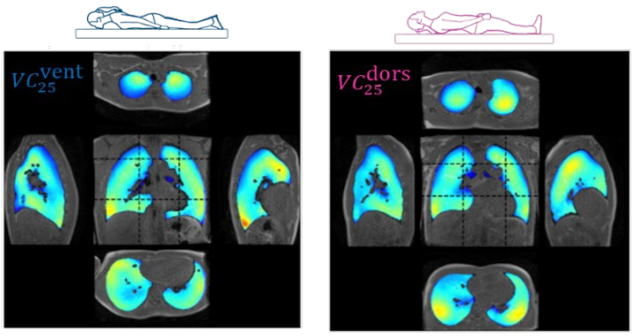
3. PhD environment

This PhD work will be carried out both at Siemens Healthineers and at BioMaps (Cifre grant). It will be supervised by Vincent Lebon (CEA PU-PH), Aurélien Massire (Siemens), and Xavier Maître (CNRS). This project is in close collaboration with researchers (INRIA, IPP, AMT) and medical doctors (Bicêtre, Foch, La Pitié-Salpêtrière, Erasmus MC).
During the thesis, lung data acquisition and image reconstruction (BioMaps, Bicêtre, Foch, La Pitié-Salpêtrière, Erasmus MC, Siemens), lung image analysis (BioMaps) and biomechanical modelling (INRIA) will be developed and performed.
The work is part of the European V|LF-Spiro3D project led by BioMaps (2023-2027). This project brings together eleven partners (three physical and mathematical modelling laboratories, one philosophical laboratory, four hospitals, two industrial companies and one patient association) from four European countries (France, Germany, the Netherlands and the United Kingdom).

4. Skills

The doctoral student will have a master's degree in biomedical imaging and a strong aptitude for programming (Python, Matlab). As part of the thesis, the doctoral student will work in a multidisciplinary environment, with experts in various scientific fields and develop knowledge and techniques in medical imaging, particularly MRI, sequence programming, signal processing, image analysis, artificial intelligence and biomechanical modelling.





5. Contacts

Supervisor : Vincent Lebon +33 1 69 86 77 01 vincent.lebon@cea.fr
Co-advisors : Aurélien Massire aurelien.massire@siemens-healthineers.com
Xavier Maître +33 6 64 35 63 98 xavier.maitre@cnrs.fr

6. Références - References

- Boucneau T, Fernandez B, Larson P, Darrasse L, & Maître X (2020) 3D Magnetic Resonance Spirometry *Scientific Reports* 10(1) 9649, https://doi.org/10.1038/s41598-020-66202-7.
- Tanguy Boucneau (2019), Magnetic resonance imaging of respiratory mechanics.
- Nathalie Barrau (2024), 3D MR Spirometry.