JOB TITLE Two-year Postdoc position in Artificial intelligence for fluid mechanics modeling

RESEARCHER PROFILE Postdoc

Substitution of Fluid Mechanics Numerical Models with Deep Learning Models. Applications to Vascular Pathologies.

This project is supported by a multidisciplinary consortium composed of researchers specializing in fluid mechanics, biomechanics, statistics, artificial intelligence, and medical imaging. The biomechanics team at the Institute of Research on Non-Equilibrium Phenomena (UMR7342, Marseille), the Econometrics and Statistics team at AMSE (UMR7316, Marseille), and CRMBM (UMR7339, Marseille), in collaboration with the medical imaging and vascular surgery services at La Timone Hospital, aim to develop a clinical diagnostic tool capable of early predicting the evolution of thoracic aorta pathologies.

The criteria commonly used in routine clinical practice to evaluate the evolution of some of these aorta pathologies, such as aneurysms, are not sufficiently discriminative to predict the best treatment early. This project aims **to determine, through numerical modeling and subsequently deep learning techniques, which physical quantities may be correlated with an unfavorable evolution, thereby improving patient management**.

The biomechanics team at IRPHE conducts complex numerical modeling of these pathologies using data from medical imaging: CT scans for geometry and MRI (2D+t, 3D+t, dynamic cine) for boundary conditions. The goal is to implement patient-specific 3D models that account for fluid and structural characteristics for different types of evolution—both favorable and unfavorable—at multiple post-operative times. This allows the association of physical quantities related to flow dynamics and structures with certain unfavorable clinical evolutions ([1]) and, in turn, to predict the early progression of the disease. However, the computation time associated with these complex models presents an obstacle to their use in clinical practice. **Therefore, the main objective of this project is to implement deep learning techniques to replace these numerical models** in order to predict the early progression of thoracic aorta pathologies. **Aneurysms of the thoracic aorta will be particularly studied**.

The biomechanics team at IRPHE (V. Deplano) has already carried out numerical modeling of aortic dissections accounting for fluid structure interactions ([2]) and is currently working on biomimetic numerical modeling of thoracic aortic aneurysms ([3]). Clinical data are obtained through collaborations with the vascular surgery (M. Gaudry & M. De Masi) and imaging (A. Jacquier) departments at La Timone. MRI sequences allowing the integration of patient-specific boundary conditions are implemented in collaboration with CRMBM. B. Ghattas (AMSE) uses and develops approaches in statistical learning and deep learning for medical applications. He has already developed automatic segmentation algorithms and medical image modeling based on deep neural networks [(4)]. He will be involved in deploying these methods dedicated to engineering science problems, such as those encountered in the numerical modeling of vascular diseases [(5), (6)]. Preliminary work on the subject has been conducted and will serve as the basis for this project [(7)].

[1] Deplano et al, (2022) Geometric vascular singularities, hemodynamic markers and pathologies. doi.org/10.1002/9781119986607.ch3. In Biological flow in large vessels; Dialog between numerical modeling and in vitro/in vivo experiment, Edition ISTE−WILEY, SCIENCES − Mechanics, ISBN :9781789450651, p 69-99

[2] Deplano, V. et al (2024) Fluid Structure interaction in aortic dissections (Chapter 25) in BIOMECHANICS OF THE AORTA: MODELLING FOR PATIENT CARE, Elsevier Textbook. https://hal.science/hal-04232191

[3] Baudouard, M., Guivier Curien, C., Rappachi, S, Jacquier A., Deplano, V. (2025) Assessing the displacement of thoracic aortic aneurysms with magnetic resonance imaging for a biomimetic numerical modeling. Submitted to Biomechanics and Modeling in mechanobiology. Preprint https://www.researchsquare.com/article/rs-6157089/v1

[4] J. Fournel, A. Bartoli, D.Bendahan, M. Guy, M. Bernard, E. Rause, M. Y.Khanjif, S.E. Petersen, A. Jacquier, B. Ghattas. Medical image segmentation automatic quality control: A multi-dimensional approach. In press, Medical Image Analysis, 2021

[5] Liang et al, (2020) A Feasibility Study of Deep Learning for Predicting Hemodynamics of Human Thoracic Aorta J. of Biomech., 99.

[6] Fukami et al, (2019) Super resolution reconstruction of turbulent flows with machine learning, J. Fluid Mech., 870

[7] O.L. Cruz González, V. Deplano, B. Ghattas, « Enhanced Vascular Flow Simulations in Aortic Aneurysm via Physics-Informed Neural Networks and Deep Operator Networks ». Submitted to Engineering Applications of Artificial Intelligence, 2025 [Preprint]. arXiv. https://arxiv.org/abs/2503.17402

TYPE OF CONTRACT: ■ TEMPORARY
JOB STATUS: ■ FULL TIME
HOURS PER WEEK __35_____
APPLICATION DEADLINE: 31/06/2025
ENVISAGED STARTING DATE: 01/10/2025
ENVISAGED DURATION: 24 months
WORK LOCATION(S): Aix Marseille School of Economics, 5-9 Bvd Maurice Bourdet 13001, Marseille.
WHAT WE OFFER: Personalized double GPU machine.
HOW TO APPLY
E-mail: badihghattas@gmail.com , valerie.deplano@univ-amu.fr
Website: http://ghattas.free.fr/

QUALIFICATIONS, REQUIRED RESEARCH FIELDS, REQUIRED EDUCATION LEVEL, PROFESSIONAL SKILLS, OTHER RESEARCH REQUIREMENTS

A phD in applied Mathematics, artificial intelligence or Mechanics with good skills in programming with python (keras, pytorch, numpy, pandas,…) and data manipulation and management.

Soft skills: Autonomy, Teamwork, Analytical and critical thinking, Listening and observing, Flexibility and adaptability, communicative.

ELIGIBILITY CRITERIA, SELECTION PROCESS
Diplomas certificate, Fluent English writing and speaking, Programming ability.
A practical exercise may be suggested according to candidates' experience.

REQUESTED DOCUMENTS OF APPLICATION: CV, Two Recommendation letters.

Additional information: The Euraxess Center of Aix-Marseille Université informs foreign visiting professors, researchers, postdoc and PhD candidates about the administrative steps to be undertaken prior to arrival at AMU and the various practical formalities to be completed once in France: visas and entry requirements, insurance, help finding accommodation, support in opening a bank account, etc. More information on AMU EURAXESS Portal