Marie Curie Doctoral position at:
- Mines Saint- Étienne - Université de Lyon (France)
- RINA Consulting (Italy)

ESR07 - Patient-specific prediction of aneurysm growth and rupture in the ascending thoracic aorta

Keywords: biomechanics, Aneurysm, Multi-Physics Simulation, Patient-specific Models, identification, virtual fields method.

General framework: 14 Early Stage Researchers (ESRs) will be offered doctoral positions as part of the MeDiTATe project, which is funded through the H2020 program: Marie Skłodowska-Curie Actions (MSCA) Innovative Training Networks – European Industrial Doctorate. The whole MeDiTATe project aims to develop state-of-the-art image based medical Digital Twins of cardiovascular districts for a patient specific prevention and treatment of aneurysms. The individual research projects of each ESR within MeDiTATe are defined across five research tracks: (1) High fidelity CAE multi-physics simulation with RBF mesh morphing; (2) Real time interaction with the digital twin by Augmented Reality, Haptic Devices and Reduced Order Models; (3) HPC tools, including GPUs, and cloud-based paradigms for fast and automated CAE processing of clinical database; (4) Big Data management for population of patients imaging data and high fidelity CAE twins; (5) Additive Manufacturing of physical mock-up for surgical planning and training to gain a comprehensive Industry 4.0 approach in a clinical scenario.
The work of each ESR, hired for two 18 months periods (industry + research) and enrolled in a PhD programme, will be driven by the multi-disciplinary and multi-sectoral needs of a multi-disciplinary research consortium (clinical, academic and industrial) which will offer the expertise of Participants to provide scientific support, secondments and training. Recruited researchers will become active players of a strategic sector of the European medical and simulation industry and will face the industrial and research challenges daily faced by clinical experts, engineering analysts and simulation software technology developers.
During their postgraduate studies they will be trained by the whole consortium receiving a flexible and competitive skill-set designed to address a career at the cutting edge of technological innovation in healthcare. The main objective of MeDiTATe is the production of high-level scientists with a strong experience of integration across academic, industrial and clinical areas, able to apply their skills to real life scenarios and capable to introduce advanced and innovative digital twin concepts in the clinic and healthcare sectors.

Description of the ESR project: The researcher will study the multiscale constitutive model previously developed by the Mines Saint-Etienne institution, which will be subject to further development and calibration. The model is developed in the framework of continuum micromechanics and large strain theory, and accounts for the presence of two layers (namely adventitia and media), and for fiber networks and cell populations within these layers. The model has been integrated within a finite-element framework in the Abaqus software. The ESR will first extend the model to account for growth and remodelling (including e.g. damage of constituents, formation of other constituents, based on the mechanical stimuli sensed by the cells) and integrate these changes in the finite element model accordingly. The model will then be applied to simulate the growth of ATAA (ascending thoracic aorta aneurysm) in patients for whom we have reconstructed the aortic geometry for several years (in cooperation with the University Hospital of Saint-Etienne). Thanks to training seminars attended during short visits at RINA Consulting, the ESR will deepen his/her knowledge on computational fluid dynamics and RBF morphing approaches. Such methodologies will enable the researcher to have

access not only to patients' geometry, but also to hemodynamics through CFD analyses combined with 4D MRI. This hemodynamics information will be coupled to the finite-element model, so as to study the impact of hemodynamics on the arterial growth and remodelling and the other way around. All these methods will be used on the data of a cohort of more than 20 patients in order to better understand how aneurysms grow and how the damage localizes in the tissue. During one month secondment at FTGM the researcher will gain insights on experimental tests concerning the mechanical characterization of specimen. During the period at Rina Consulting, the PhD student will work on automating the numerical processes through scripts aimed at combining commercial and/or open source solvers. After a preliminary assessment, the Python programming language for designing the scripts driving computational processes, the ABAQUS and Code Aster codes to run the structural analyses, and ANSYS Fluent and SimVascular software to perform CFD analyses have been identified as possible candidates.

Additional Information:
The ESR will be enrolled in the PhD programme of University of Lyon at Mines Saint-Etienne, France. The PhD thesis will take place at two different places: (a) Mines Saint-Etienne (France) in the CIS department, which conducts major international research projects in the field of soft tissue biomechanics, in particular aortic aneurysms. The ESR will collaborate with other researchers involved in ERC projects (https://www.mines-stetienne.fr/en/author/avril/, https://www.emse.fr/~badel/); (b) RINA Consulting (Italy – Rome), where the researcher will be trained on CFD modelling and mesh morphing and will work on numerical processes automatization. RINA Consulting is experienced in mesh morphing and computational fluid dynamics applied to hemodynamics applications (https://www.researchgate.net/profile/Emiliano_Costa3). A one-month secondment in the Fondazione Toscana G. Monasterio (Italy) is foreseen.

Benefits, salary and duration:
The selected candidate will receive a salary in accordance with the MSCA regulations for ESR. The gross salary includes a living allowance (€3,270 per month, subject to MSCA country correction coefficient, i.e. 115.7% for France and 104.4 % for Italy), a mobility allowance (€600 per month), and a family allowance (€500 per month, if the researcher has family by the date of recruitment, regardless of whether the family will move with the researcher or not). The guaranteed funding is for 36 months (i.e. EC funding).

Eligibility criteria:
Applicants can be of any nationality and must hold a Master of Science degree (or equivalent) in engineering. They need to fully respect both eligibility criteria (to be demonstrated in the Europass CV): (a) Early-Stage Researchers (ESRs) must, at the date of recruitment by the beneficiary, be in the first four years (full-time equivalent research experience) of their research careers and have not been awarded a doctoral degree. (b) Conditions of international mobility of researchers: Researchers are required to undertake trans-national mobility (i.e. move from one country to another) when taking up the appointment. At the time of selection by the host organization, researchers must not have resided or carried out their main activity (work, studies, etc.) in France for more than 12 months in the 3 years immediately prior to their recruitment. Short stays, such as holidays, are not taken into account.

Candidate profile: Candidates with strong skills in mechanics (modelling) and biomechanics are expected. Motivation and interest in bioengineering applications is recommended. Excellent knowledge of written and spoken English is required.

How to apply: Send CV, cover letter, BSc and MSc degrees, and letters of recommendation to all the following recipients: avril@emse.fr and emiliano.costa@rina.org.