ESR03 - Modelling and 3D printing for intracranial aneurysms surgery

Keywords: biomechanics, Aneurysm, Computational Mechanics, Real-Time simulation, Patient-specific Models, Machine Learning, 3D Printing.

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 aim of the project is the development and validation of real-time tools for the visualization and simulation of interventions in intracranial aneurysms. Both 3D printed and virtual models will be developed in a complementary manner. The virtual models should be able to simulate, in real-time, the combined mechanics of coils and their contact against the deformable, patient-specific aneurysm. The candidate will also build a 3D phantom to be used for validation and visualization purposes.

3D printed and virtual representations of the Digital Twin will have a number of advantages consisting in the possibility of: planning in urgent conditions the optimal surgical treatment of broken aneurysms based on specific aneurysm morphology; to study, plan and simulate non-broken and complex aneurysms; to implement training for aneurysm clipping interventions. For the achievement of the objectives, four phases of the research activities are planned: development of the computational model, 3D printed models for validation of simulations and

visualization purpose, Clinical Trials, system integration between diagnostic, simulation and additive manufacturing equipment.

Additional Information:
The ESR03 will be enrolled in the PhD programme of University of Lyon at Mines Saint-Etienne, France. The PhD thesis will take place at 2 different places: (a) Predisurge, Saint Étienne (France) which aims at developing software solutions to achieve better training, preoperative planning and intervention in the cardiovascular domain. Software is based on numerical finite-element simulation, a technology that allows predicting how tools and devices will behave in patient-specific vascular anatomy. Predisurge is a spin-off of Mines Saint-Etienne (France) and is based in the CIS department, which conducts major international research projects in the field of soft tissue biomechanics, in particular aortic aneurysms. ESR3 will collaborate with other researchers of CIS involved in ERC projects (https://www.mines-stetienne.fr/en/author/avril/, https://www.emse.fr/~badel/); (b) Università Degli Studi di Roma Tor Vergata (Italy) in the Department of Enterprise Engineering which is interested in shape optimization of structural parts, shape optimisation using mesh morphing and CFD (automotive, nautical, naval, aeronautic), fluid structure interaction (reed valves, vessels, aircraft wings), vibrations of orthotropic plates, advanced use of RBF (image analysis of deformations, flow fields interpolation) and large-scale high-fidelity numerical simulations of turbulent flows in complex geometric configurations. Two one-month secondments will take place at HSL srl, Trento (Italy) and at Università di Ferrara (Italy).

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 background in mechanics and programming are expected. Previous experience in programming Finite Element and/or Machine Learning algorithms is a plus. Motivation and interest in bioengineering and additive manufacturing 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, biancolini@ing.uniroma2.it and david.perrin@predisurge.com.