Marie Curie Doctoral position at:
- ESI Group – Paris (France)
- National Technical University of Athens (Greece)

ESR05 - HiFi flow solvers for flexible walls, running on GPUs, and Big Data Analysis for aneurysm studies

Keywords: Computational Structural Mechanics, Computational Fluid Dynamics, Fluid-Structure Interaction, Big Data, Deep Neural Networks, GPUs.

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 first objective of ESR5 is the extension of an in-house GPU-enabled CFD code, developed by the National Technical University of Athens, to accommodate moving walls by incorporating a generic wall thickness model and Fluid-Structure Interaction (FSI) techniques for the unsteady flow simulation inside the aneurysm. A method based on Deep Neural Networks (DNN) will be also considered to replicate the time-steps of the CFD run. The structural problem within the solid region will be treated using the finite element method (FEM). Both domains are coupled at the interface, i.e. at the luminal surface, where data will be exchanged. Results of the simulations will be visualized to understand the hemodynamic flow patterns in aneurysms. Available patient data, considered as Big Data, will be studied using and improving the data analytics options of the ESI Mineset proprietary software and other techniques like Regression Trees, Decision Trees, Random Forest, etc. Accurate low-cost mechanisms of adapting the computational grids to the changing interface and the communication of interfacial data in a conservative manner will be

investigated. Simple Fluid-Solid-Growth models of cerebral aneurysm evolution, according to the existing literature, which combine fluid and solid mechanics analyses of the vascular wall with the kinetics of biologic growth and re-modelling, will be used. The models can further be extended by using the available patient data. A DNN will be trained based on real data to predict the cerebral aneurysm evolution and validate the existing Fluid-Solid-Growth models.

Additional Information:
ESR5 will be enrolled in the PhD programme of the School of Mechanical Engineering of the National Technical University of Athens (NTUA), Greece. The ESR5 individual project will be realized: (a) at the ESI Group – Paris (France), in the Scientific Department headed by Prof. F. Chinesta who is a world recognized authority in Model Order Reduction methods. Within this department is also Dr. A. Kamoulakos who has expertise in the numerical structural analysis and associated materials modelling and who will supervise in conjunction with Prof. Chinesta the ESR; (b) at the NTUA (Parallel CFD & Optimization Unit, PCOpt). The PCOpt/NTUA, headed by Prof. K. Giannakoglou has great experience in developing CFD tools, optimization methods (adjoint & evolutionary algorithms) and applying them in single and multi-disciplinary real-world problems (see: http://147.102.55.162/research/). 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 88.7% for Greece), 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 Computational Structural Mechanics, Fluid-Structure Interaction (primarily) and Computational Fluid Dynamics (secondarily) background should apply for this position. Good programming skills (FORTRAN, C++, Python and optionally CUDA) are needed. Some background in Artificial/Computational Intelligence, and Big Data is welcome. Motivation and interest in Structural Mechanics, Multi-physics, Machine Learning and Biomedical engineering is preferable. 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: aka@esi-group.com and kgianna@mail.ntua.gr.