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

ESR04 - HiFi flow solvers for fixed walls, running on GPUs, and ROMs for aneurysm studies

Keywords: Computational Fluid Dynamics, Reduced Order Models, GPUs, Parallel Computing, Computational Structural Mechanics.

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 objective of ESR4 is to integrate and use a CFD model to simulate the flow in aneurysms, assuming rigid nonflexible walls with infinite resistance, running on GPU clusters; the NTUA, GPU-enabled, finite-volume URANS code version will be used as the background tool. Modifications will be performed to accommodate varying fluid properties. ESR4 will be responsible for (a) processing data from computed tomography (CT), grid generation and post-processing of results for visualization purposes. Emphasis will be given to the memory handling, so as to minimize MPI-based inter-board communications. Next to this, ROM techniques will be examined for the CFD computations and, in particular, the concepts of HyperReduction, POD, PGD and Artificial Neural Networks (contribution by ESI). Studies with Newtonian fluid model and variable viscosity will be carried out. Geometric quantities (aneurysm length, maximum diameters, etc.) and the associated non-dimensional metrics or indices of the aneurysm will be correlated with the hemodynamic loads and the rupture risk. Studies will focus on estimates of the aneurysm rupture risk. The rupture risk will

be examined within suitable HiFi arterial wall simulations using the EWK model of the VPS s/w by ESI. An artificial neural network will be created to represent the detailed rupture within a global FE model. By doing so, CFD can improve the understanding of factors determining the origin and progression of aneurysms. Moreover, trained Deep Neural Networks will be used to predict the failure points of the arterial wall, the origin and the progress of the aneurysms by avoiding the expensive CFD process.

Additional Information:
ESR4 will be enrolled in the PhD programme of the School of Mechanical Engineering of the National Technical University of Athens (NTUA), Greece. The ESR4 individual project will be realized at: (a) 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/); (b) 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. 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. 88.7% for Greece and 115.7% for France), 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 Greece 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 Fluid Mechanics, Computational Fluid Mechanics (primarily) and Computational Structural Mechanics (secondarily) background should apply for this position. Good programming skills (FORTRAN, C++, Python and optionally CUDA) are needed. Some background in Artificial/Computational Intelligence techniques is welcome. Motivation and interest in Fluid Mechanics, Multi-physics, Biomedical engineering and Artificial Intelligence 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: kgianna@mail.ntua.gr and aka@esi-group.com.