Marie Curie Doctoral position at:
- National Technical University of Athens (Greece)
- Technevalue GmbH – Bäch (Switzerland)

ESR06 - Uncertainty Quantifications, using Polynomial Chaos Expansion, of CFD predictions for aneurysm studies

Keywords: Uncertainty Quantification, Polynomial Chaos Expansion, Big Data, CAD-free morphing.

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 main objective of ESR6 is to identify hemodynamic variables which are of greatest importance in aneurysm stabilization or rapture, through sensitivity studies. The work will be based on uncertainty quantification (UQ) for any quantity of interest (QoI; asymmetry metric, saccular index, deformation diameter rate, tortuosity index, etc.) realized through the non-intrusive Polynomial Chaos Expansion (PCE) method, using a developed CFD/Fluid-Structure Interaction software as black-box. UQ computes the statistical moments (mean values and standard deviations usually suffice) of the output of a simulation, for uncertainties to the problem inputs/data. By assuming a Probability Density Function for each uncertain variable, according to the PCE theory, the QoI is expressed as a linear combination of orthogonal polynomials. Polynomial (or PCE) coefficients are computed by running the CFD/FSI tool at a number of data-sets and, then, integrating. The sought statistical moments are given by closed-form expressions of the PCE coefficients. Using clinical images of changes in aneurysm wall position during the cardiac cycle, a wall motion model will be built

and used in the CFD/FSI simulation. The sensitivity of the simulation results to small changes of the input variables will be investigated. Shape imperfections and wall movement will be realized computationally by CAD-free techniques and a morphing/smoothing tool that adapts the volume computational mesh to any boundary shape.

Additional Information:
ESR6 will be enrolled in the PhD programme of the School of Mechanical Engineering of the National Technical University of Athens (NTUA), Greece. The ESR6 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 Technevalue GmbH – Bäch (Switzerland) which is a young and dynamic entrepreneurial venture, providing superior and innovative business IT solutions. Its area of expertise consists of multi-channel customer service and support. It has a special experience on Big Data science, intended to be brought in the Medical Digital Imaging field. 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 121.2% for Switzerland), 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 Computational Mechanics (Fluid/Structural as well as their interaction), Artificial/Computational Intelligence and Big Data should apply for this position. Good programming skills (C++, Python and optionally CUDA) are needed. 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: kgianna@mail.ntua.gr and mauro.odino@technevalue.com.