MeDiTATe project
Newsletter N°1 – December 2022

The MeDiTATe project aims to deliver new technologies targeted at industrial and clinical-translation to accelerate the process of personalized cardiovascular medical procedures, validated through an integrated experimental programme to improve patient care. This issue of the newsletter focuses on the main advancements of the MeDiTATe project. After more than two years of the project, we want to take a look at where we are now. During this period several activities in term of high level formation courses have been carried out performed by both industrial and academic partners. Moreover, relevant research contributions with respect to the state of the art have been finalised by our 14 Early Stage Researchers in all the topics of the MeDiTATe project: 3D printing, advanced computational modelling, experimental activities and artificial intelligence. Papers are already published, other are incoming in the first months of the new year. Some of our ESRs are concluding their PhD period and they are finalising their PhD Thesis. Please enjoy reading about the latest activities of our ESRs!

Featured News

A new MeDiTATe project publication: A Hybrid Mock Circulatory Loop for Fluid Dynamic Characterization of 3D Anatomical Phantoms

Francesco Bardi, ESR 10 of the MeDiTATe project, published the paper titled A Hybrid Mock Circulatory Loop for Fluid Dynamic Characterization of 3D Anatomical Phantoms on the IEEE Transactions on Biomedical Engineering journal.

The work was developed in collaboration with Emanuele Gasparotti, Emanuele Vignali and Simona Celi from Bioengineering Unit (Fondazione Toscana G.Monasterio) and Stéphane Avril from Mines Saint-Étienne.

The paper, whose abstract is reported in the following lines, is available at this link.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 859836.

This work presents the development of a Hybrid Mock Circulatory Loop (HMCL) to simulate hemodynamics at patient-specific level in terms of both 3D geometry and inlet/outlet boundary conditions. Methods: Clinical data have been processed to define the morphological and functional patient-specific settings. A piston pump is used to impose a parametric flow rate profile at the inlet of the hemodynamic circuit. In order to guarantee the physiological pressure and flow conditions, a specific hybrid chamber system including a real-time control has been designed and implemented. The developed system was validated firstly in a single outlet branch model and, secondly, on a 3D printed patient-specific multi-branch phantom. Finally, for the 3D phantom, the outlet flow profiles were compared with the corresponding in-vivo flow data. Results: Results showed that the root mean squared error between the prescribed setpoint and the measured pressures was always below 3 mmHg (about 2.5%) for all cases. The obtained flow profiles for the patient-specific model were in agreement with the related functional in-vivo data. Significance: The capability to reproduce physiological hemodynamics condition, with high-fidelity, plays a significant role in the cardiovascular research. The developed platform can be used to assess the performances of cardiovascular devices, to validate numerical simulations, and to test imaging systems.

Inauguration ceremony for CINECA's Supercomputer LEONARDO

Last November 24th, the Inauguration Ceremony of CINECA's LEONARDO Pre-Exascale Supercomputer was held at Bologna Technopole, Italy.

LEONARDO, jointly funded by EuroHPC and CINECA (one of the MeDiTATe project partners) on behalf of the Italian Ministry of University and Research, has ranked 4th in the latest Top500 list of most powerful supercomputers in the world.

LEONARDO is one of the three pre-exascale systems of the EuroHPC Joint Undertaking (EuroHPC JU). The project is part of the actions that the European Union has been implementing to support the spread of High Performance Computing for research applications.

For more information on LEONARDO technical details visit Cineca's dedicated page.

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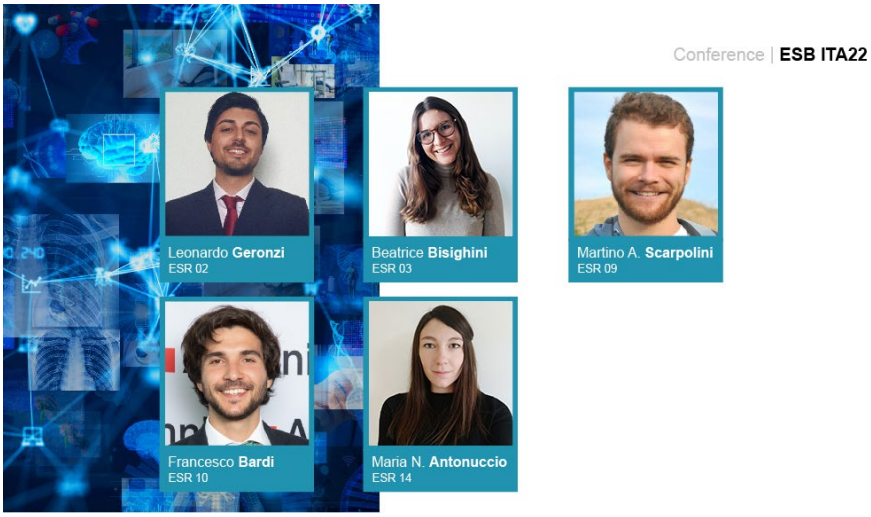
Events

The MeDiTATe project at the XI Annual Meeting of the Italian Chapter of the European Society of Biomechanics (ESB-ITA)



The MeDiTATe project participated in the XI Annual Meeting of the Italian Chapter of the European Society of Biomechanics (ESB-ITA22). The event, hosted by the BioCardioLab group from Fondazione Toscana G. Monasterio, was held in Massa (Italy) on 6th and 7th October, 2022. Five of our Early Stage Researchers presented the results of their work, described in the following lines.

Leonardo Geronzi – ESR 02: A method to calibrate the mechanical boundary conditions of a high-fidelity thoracic aorta model. In this work, a calibration of the mechanical boundary conditions for a thoracic aorta model was performed, including the effect of the soft tissue, the interaction of the vessel with the spine and the motion due to the heart. We minimised the discrepancy between the splines derived from the segmented boundaries of cine magnetic resonance imaging (cine-MRI) data and the respective splines built from the deformed computational model. We then performed fluid-structure interaction analysis with the calibrated patient-specific model studying the effect of the heart motion on the aortic wall.

Beatrice Bisighini – ESR 03: Towards a real-time simulator of flow diverters deployment based on model order reduction. With the aim of developing a computational tool to assist surgeons in the selection of the best device for patient-specific cerebral aneurysms treatment, in this study we propose a fast and accurate reduced-order modelling scheme, based on finite element simulations, to compute in real-time the deployed configuration of flow diverters within idealised vessel models.

Martino Andrea Scarpolini – ESR 09: Deploying digital twins of the cardiovascular system in clinics: a deep learning-based automatized framework. Digital twins represent a new powerful numerical tool to give personalized treatment for cardiovascular diseases, however their translation in a clinical environment is still limited mainly due to long computational times. This work shows an automatized workflow to build a real-time digital twin using deep learning algorithms and computational fluid dynamics simulations. Results show that the computation time can be reduced from hours to a few seconds.

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Francesco Bardi – ESR 10: LED illuminated PIV velocity field characterization in a patient specific aortic aneurysm phantom. The Abdominal Aortic Aneurysm (AAA) is a highly diffused life-threatening condition. In recent years, experimental and numerical techniques were demonstrated to be reliable tools for AAA investigation. Given this, a Hybrid Mock Circulatory Loop and a cost-effective LED Particle Image Velocimetry (PIV) setup were used to characterize the fluid dynamic behaviour in a compliant AAA phantom. Several boundary conditions have been tested, and the instantaneous velocity field was measured in lower part of the aneurysm.

Maria Nicole Antonuccio – ESR 14: An experimental/computational approach for fluid dynamic characterization of AAA Compliant phantoms and experimental circulatory loops have gathered importance over the years as they can reproduce hemodynamics at a patient-specific level in terms of both 3D geometry and inlet/outlet boundary conditions. If combined with medical imaging, such as echography, these tools can deepen the knowledge of cardiovascular pathologies. In this work, flow fields in an abdominal aortic aneurysm phantom are reconstructed from Color-Doppler Ultrasound images. In-silico data, obtained from Computational Fluid Dynamics, are used for further comparisons.

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MeDiTAlks

An interview with Dr. Emiliano Costa: Communication, Dissemination and Exploitation Coordinator of the MeDiTATe project.

We had a talk with Dr. Emiliano Costa, a member of the Supervisory Board of the MeDiTATe project and Principal Engineer at RINA. During his 15+ years of experience, he participated in both Italian and European co-funded research projects mainly in coordination and simulation-based tasks. In MeDiTATe he has a three-fold role: Scientist-in-Charge of RINA, Industrial Supervisor of ESR 07 and ESR 12 and Communication, Dissemination and Exploitation Coordinator.

What about RINA's experience in MSCA projects? Do you think it is important for large companies to be involved in EU-financed projects like MeDiTATe?

As far as I know, this is one of the very first experiences of RINA in MSCA projects and, since the proposal stage, it was very challenging due to the large number of beneficiaries and partners involved. Large companies like RINA can definitively benefit from projects like MeDiTATe because, as it is a further opportunity to "virtuously contaminate each other" in terms of scientific knowledge and professional experience. Apart from that, we continue enjoying a longstanding collaboration with several of the players of the consortium.

How can the vision of a large company meet the scope of the MeDiTATe project?

In the end, one of the main objectives of MeDiTATe is to help ESRs in becoming high-profile professionals and scientists from whom the world community will benefit in the future. This is the same approach of the continuous improvement culture embraced by RINA to empower employees.

How do you think ESRs can benefit from the industrial approach that RINA proposes?

Together with the colleagues involved in MeDiTATe we have been trying to share first the RINA's experience on communication and managerial topics creating, at least I hope, a positive environment to work in.

From a technical point of view, the presence and influence of private industrial entities like RINA are definitively an added value for ESRs. Our industrial-based thinking typically solicits ESRs to be more pragmatic in their daily work trying to ground their professional efforts in view of producing effective and exploitable solutions and applications.

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Can you tell us something about the activities of the ESRs that you are mentoring?

Both researchers started their activities by deepening their knowledge in computational modelling and simulations in the cardiovascular field. They were extremely committed to their training programme and, now, they are applying the acquired knowledge in the area of medical digital twins, on which they are presenting papers at congresses and submitting articles in scientific journals.

Please, leave a message for our readers.

Be curious, keep informed and have a positive attitude because there is always something to learn from everyone you find along the life path. Best, Emiliano.

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