MeDiTATe project
Newsletter N°4 – December 2023

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 achieved during the second trimester months of the 2023 where 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. Several papers are already published and most of our ESRs are concluding their PhD period. Please enjoy reading about the latest activities of our ESRs!

Scientific publications

"Prediction of guidewire-induced aortic deformations during EVAR: a finite element and in vitro study"

Monica Emendi ESR 11 of the MeDiTATe project, published the paper titled **Prediction of guidewire-induced aortic deformations during EVAR: a finite element and in vitro study"** in the **Frontiers in Physiology Journal**.
The work was developed in collaboration with other authors from the MeDiTATe project including Pierluigi Di Giovanni from HSL and Thomas Langø from SINTEF.
The paper is available at this **link**.

"Enabling supra-aortic vessels inclusion in statistical shape models of the aorta: a novel non-rigid registration method"

A new paper **"Enabling supra-aortic vessels inclusion in statistical shape models of the aorta: a novel non-rigid registration method"** has been published in the **Frontiers in Physiology Journal**. The paper was written by **Martino Andrea Scarpolini** ESR 09 as well as by Dr **Simona Celi** Ethic Coordinator of the MeDiTATe project.
The full paper 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.

"Fabrication of deformable patient-specific AAA models by material casting techniques"

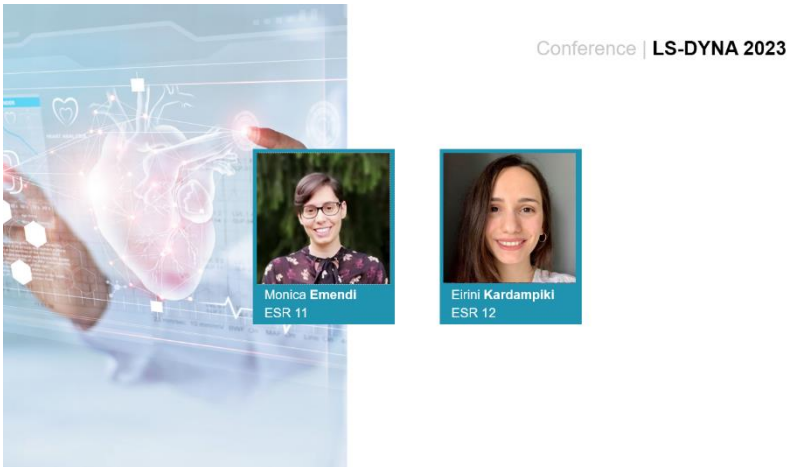
A new paper **"Fabrication of deformable patient-specific AAA models by material casting techniques"** has been published in the **Frontiers in Cardiovascular Medicine Journal**. The paper was authored by **Maria Nicole Antonuccio (ESR 14)** as the first author, **Francesco Bardi (ESR10)** and other authors from the MeDiTATe project including **Dr Simona Celi** (Ethic Coordinator of the MeDiTATe project) and Prof. **Stéphane Avril** (Research Coordinator of MeDiTATe project). The full paper is available at this **link**.

Events

14th European LS-DYNA Conference

The MeDiTATe project were present at the **14th European LS-DYNA Conference**. The event took place in Baden-Baden, Germany on October 18 and 19, 2023.

In this occasion, **Eirini Kardampiki (ESR 12)** presented the results of her activities with an oral presentation whose title is "Reduced Order Model for enhanced EVAR Planning and navigation guidance". The work is also authored by **Monica Emendi (ESR 11)** and other authors from the MEDITATE project including **Marco Evangelos Biancolini**, Principal Investigator of the MeDiTATe project.

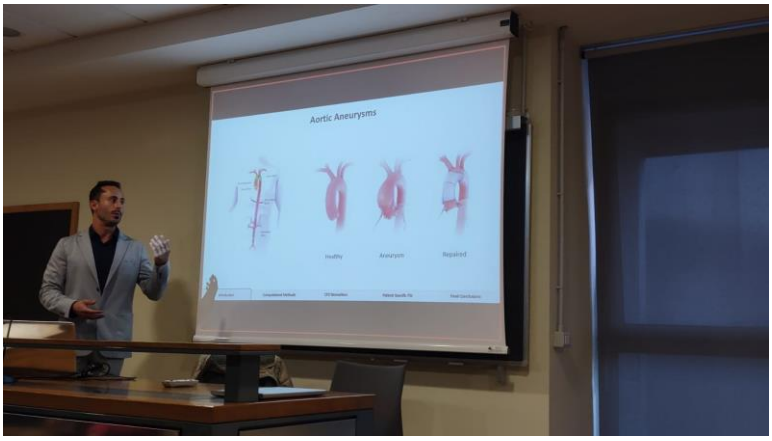


An abstract describing their joint work is as follows: *"The pre-operative planning and navigation guidance of endovascular aneurysm repair (EVAR) are challenged by the abdominal aortic deformation caused by the insertion of a stiff guidewire during the procedure. Currently, clinicians operate with the support of imaging fusion techniques but still there is a mismatch between the pre-operative CT and the intra-operative aortic configuration. Thus, the use of contrast agent is needed to visualize the vessels. High-fidelity Finite Element simulations can predict the aortic wall deformations, but they are time-demanding, thus not compliant with the clinical timeframe. To tackle this limitation, we developed a parametric Reduced Order Model which predicts the aortic motion in function of seven critical parameters. The accuracy of the proposed ROM was found to be sufficient compared to the resolution of the currently used imaging technologies. The ROM response was provided within some second, showing potential of being employed pre- and intra-operatively."*
More details **here.**

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.

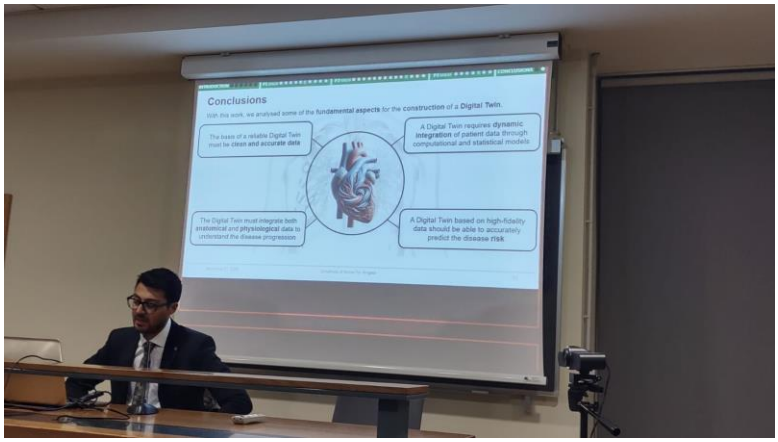
Acknowledgements and results

Antonio Martinez successfully defended his PhD thesis defense



On December 1st, Antonio Martinez, ESR01 of the MeDiTATe project successfully defended his PhD thesis at the University of Rome "Tor Vergata". The title of his work was "Computational Methods for the Analysis of Ascending Aortic Aneurysms".
Antonio demonstrated how to carry out a patient-specific assessment of the aorta's condition including an estimation of expected growth. The main novelty of the proposed approach lies in the obtained correlation of the biomarkers with aneurysm growth rate. Additionally, patient specific FSI models were developed, accounting for personalized aortic wall models and calibrated hemodynamics extracted from MRI 4D, which achieved a fidelity level beyond the state of the art..

Leonardo Geronzi successfully defended his PhD thesis defense



On December 1st Leonardo Geronzi, ESR02 of the MeDiTATe project successfully defended his PhD thesis at the University of Rome "Tor Vergata". The title of his work was "Towards Digital Twin Technologies for Ascending Aortic Aneurysm Growth Prediction and Real-Time Diagnosis".

Leonardo demonstrated how to structure a Digital Twin of the aorta based on high-fidelity numerical simulation, integrating methods for aneurysm growth and risk prediction and using surrogate modeling techniques to achieve real-time hemodynamic assessment.

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.

MeDiTAlks

An interview with Prof. Stéphane Avril, Research Coordinator of the MeDiTATe project

We had a small talk with Prof. Stéphane Avril, a member of the Board of the MeDiTATe project. He is a Distinguished Full Professor at Mines Saint-Etienne (France) and co-founder of Predisurge. He has a strong mechanics and biomechanics background as a scientist and as an entrepreneur. He has a long mentoring experience as a Professor of soft tissue biomechanics and as director of the center for biomedical and healthcare engineering at Mines Saint-Etienne. In total he advised or co-advised more than 45 PhD students and mentored 25 post-docs. Teaching and mentoring experience of Stéphane Avril extends to the organization of summer or advanced school in soft tissue biomechanics (he organized 2 advanced schools of the International Center for Mechanical Sciences (CISM) in 2015 and 2017. He guides ESR 07 and ESR 08 in view of his strong expertise in computational biomechanics and supports ESR 03, ESR 10, ESR 13 and ESR 14 for all the advanced biomechanics related topics.

1. **The MeDiTATe project, a research proposal funded by the European Commission in the framework of Horizon 2020 programme. Can you tell us more about Mines Saint-Etienne and its role in the project?**

Mines Saint-Etienne (MSE), founded in 1816, is one of the most prestigious engineering schools in France, ranked in the top 10 graduate schools of engineering. Close links with the corporate world, project-based teaching and innovation are the main assets of the engineering school. In January 2017, Ecole des Mines de Saint-Etienne became part of Institut Mines Télécom (IMT). IMT (https://www.imt.fr/en/) is a national public institution dedicated to higher education, research and innovation in engineering and digital technologies. The institution is under the authority of the Minister for Industry.

The center for biomedical and healthcare engineering (CBHE) is with an INSERM endorsed research unit (SAINBIOSE: U1059) and one of the largest centres for biomedical engineering in France. Composed of 17 permanent faculty members and 40 PhD students and postdocs, and headed by Prof. V. Augusto, its research topics are multidisciplinary, combining engineering and health science. The biomechanics group head by Prof. S. Avril aims to carry out fundamental investigations in the domain of mechanical identification of soft tissues and prostheses, with strong interactions with medical device industries and with the Saint Etienne University Hospital (SEUH).

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.

The biomechanics group, which is the group involved in Meditate, is renowned internationally for its research aimed at improving the treatment of cardiovascular diseases by assisting physicians and surgeons with biomechanical numerical simulations. Recent research directions include: AAA wall mechanics using FEA and growth & remodeling simulations. This fits perfectly with Meditate's goal to develop digital twins of aortic aneurysms. We supervise 6 ESRs: ESR3, ESR7, ESR8, ESR10, ESR13 and ESR14, all related to computational modelling of the aorta or of endovascular procedures.

2. **Let's talk about the idea behind MeDiTATe. The project received funding from the EU in the Framework of Horizon 2020 programme, therefore it is clear that the proposed approach meets the EU's ambition to exploit scientific research to improve the treatment of the cardiovascular diseases and patient care. In particular, how can the scientific community benefit from your work?**

The Meditate projet has led to a significant number of publications in peer-reviewed international journals, highlighting the quantity of scientific results obtained by the ESRs. We also filed at least 4 patents which will be exploited by companies like Predisurge (start-up providing numerical simulations as a service to hospitals and medtech companies with digital twins of the aorta) or Philips (ultrasound division). Another benefit of Meditate is the very advanced training of ESR who will become ambassadors of the digital twin technologies we have been developing, to diffuse them in academia and in the industry.

3. **How can the digital Twins developed in Meditate be useful for patient's care?**

Thanks to digital twins developed in Meditate, endovascular aneurysm repair has become safer and safer and all patients with an aortic aneurysm have become eligible to these procedures. Moreover, aneurysm biomechanics can now be monitored by combining medical imaging and digital twins developed in Meditate. When they reach all hospitals, these technologies will permit to fully eradicate aneurysm ruptures, saving 30000+ lives every year across the world.

4. **Professor Avril, the MeDiTATe project has reached the end. What are your thoughts on the achievements at this final stage of the project?**

Achievements went far beyond expectations. Thanks to an excellent management team, the project reached all its objectives despite the covid19 pandemics at the beginning. I am amazed by the number of patents and by the commitment of companies participating to Meditate. But the biggest success are the ESRs. They impressed me by the quantity and quality of their work in their PhD. I have no doubt they will all have successful careers in academia or in the industry and will keep unforgettable memories of the Meditate project.

5. **Any message for our readers?**

If you know someone around you who was diagnosed with an aneurysm, tell her or him about Meditate. She/he can mention Meditate to her/his doctor to have access to digital twin technologies in the treatment.

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.