Schedule

	Monday	Tuesday	Wednesday	Thursday	Friday
9:00 – 10:30	S. Avril	I. Vignon	P. Diez	C. Bertoglio	J. Camps
10:30 – 11:00	Break	Break	Break	Break	Break
11:00 – 12:30	M. Peirlinck	I. Vignon	S. Fresca	C. Bertoglio	J. Camps
12:30 – 13:00		Lunch	Lunch	Lunch	Lunch
13:00 – 14:00	Registration				
14:00-15:30		M. Peirlinck	S. Fresca	M. Aguirre	
15:30 – 16:00	Break	Break	Break	Break	
16:00 – 17:30	Welcome Cocktail	Poster Session	Cultural Activity	M. Aguirre / B. Bisighini / Conference dinner	

Presentation, objectives and target audience

The 1st Summer School on Reduced-Order and Data-Driven Models in Biomechanics will be held in Figueres, Spain, the 7th to 11th April 2025. The summer school is organized jointly between Mines Saint-Étienne (France), UPC and CIMNE (Spain) and the Figueres City Council. We will cover the main state of the art tools in reduced order modelling and data driven simulation in biomechanics, with a special emphasis in cardiovascular medicine. Theoretical and hands on tutorials will present a wide range of topics such as: blood flow modelling using 0D models, boundary conditions and parameter estimation in haemodynamics, deep learning based reduced order models for parametrized PDE'S, parameter estimation in ODEs and 3D-0D coupled problems, automated model discovery, digital twins in cardiology with emphasis on electrophysiology, computational models of endovascular interventions, machine-learning based virtual field methods. The summer school is targeted to PhD students, postdoctoral researchers, academics but also scientists and engineers from industry that wish to update their knowledge in the above areas.

Registration

Registration fee is 275 € which includes access to all sessions, coffee breaks, lunches (from Tuesday to Friday), welcome cocktail and conference dinner. Registration and payment via: https://rombiomechdd25.cimne.com/registration_fees.

Registration deadline: February 28 2025.

Poster presentation

We will host a poster session. If you wish to present a poster, an abstract must be submitted before January 17 2025 (https://rombiomechdd25.cimne.com/call_for_abstracts).
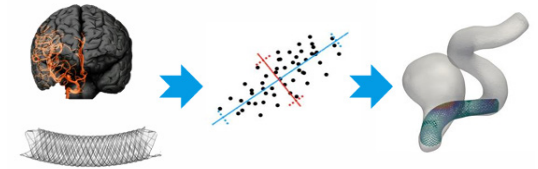
Organization

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Summer School in Reduced-order and Data-driven models in Biomechanics

Figueres (Spain) | 7-11 April 2025

rombiomechdd25.cimne.com

Coordinated by:
- Miquel Aguirre (UPC & CIMNE)
- Stéphane Avril (Mines Saint-Étienne)
- Pedro Díez (UPC & CIMNE)
- Beatrice Bisighini (Mines Saint-Étienne)

La Région Auvergne-Rhône-Alpes

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CIMNE

Ajuntament de Figueres

Invited Lecturers

Irene Vignon-Clementel (INRIA, France)

Two short courses will be given in the following content: "3D and reduced order models of blood flow: the challenges of patient-specific simulations" and "Deep-learning and mechanistic models complementarity: a few hemodynamics applications". Keywords: CFD, 0D models, POD, model coupling, parameter estimation, sensitivity analysis, unknown mechanism modeling, synthetic vs patient geometry, model speed-up.

Stefania Fresca (Politecnico di Milano, Italy)

"Deep learning-based reduced order models for parametrized PDEs". Deep-learning based ROMs for PDEs, applications in cardiac electrophysiology, computational mechanics and fluid dynamics. Keywords: scientific machine learning, reduced order modeling, neural networks, parametrized PDEs, life science applications.

Cristóbal Bertoglio (University of Groningen, The Netherlands)

"Inverse problems in lumped parameter models". Variational parameter estimation in ODEs, Sequential parameters estimation in ODEs and 3D-0D coupled problems. Keywords: parameter estimation, clinical measurements, maximum likelihood, numerical optimization.

Mathias Peirlinck (TU Delft, The Netherlands)

"Automated Model Discovery: A Hands-on programming experience". Brief history of constitutive modelling; Introduction to constitutive neural networks; Overview of mechanical testing; Automated model discovery for biological systems; Hands-On Programming Experience. Keywords: automated model discovery, constitutive neural networks, mechanical testing.

Julià Camps (University of Oxford, United Kingdom)

"Digital twins in cardiology: Bridging Mechanistic Modeling and Clinical Data for Personalized Medicine". Fundamental principles mechanistic modelling and simulation in digital twins; role of Ai physics informed ML; challenges in biological digital twins; hands-on creation of electrophysiology simulations and digital twin creation. Keywords: Phenomenological models, Bayesian inference, Modelling and simulation, Electrocardiogram, Digital twins, Jupyter notebooks, Python

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Stéphane Avril (Mines Saint-Étienne & Inserm, France)

"Introduction to biomechanics and mechanobiology", "the needs of reduced-order and data-driven models in biomechanics and mechanobiology", "Digital Twins in vascular medicine", "Computational models of endovascular interventions", "Constitutive modelling of Soft tissues", "Parameter identification using full-field optical measurements"; "Machine-learning based virtual fields method"

Miquel Aguirre (Universitat Politècnica de Catalunya & CIMNE, Spain)

"Towards real time modelling of endovascular device deployment". Introduction to endovascular devices; high fidelity models of endovascular deployment using open-source software; non-intrusive reduced order modelling; patient parametrization Keywords: beam modelling; corotational models; signed distance fields; non-intrusive reduced order modelling; contact mechanics; patient-specific geometry parametrization.

Pedro Díez (Universitat Politècnica de Catalunya & CIMNE, Spain))

"Linear and nonlinear dimensionality reduction in biomedical applications". Keywords: kernel Proper Orthogonal Decomposition; dimensionality reduction techniques; Principal Component Analysis; Reduced Basis approaches.

Suggested readings

Avril, S. (2017). Hyperelasticity of soft tissues and related inverse problems. Material parameter identification and inverse problems in soft tissue biomechanics, 37-66.

Bertoglio, C., Moireau, P., & Gerbeau, J. F. (2012). Sequential parameter estimation for fluid–structure problems: application to hemodynamics. International Journal for Numerical Methods in Biomedical Engineering, 28(4), 434-455.

Bisighini, B., Aguirre, M., Biancolini, M. E., Trovalusci, F., Perrin, D., Avril, S., & Pierrat, B. (2023). Machine learning and reduced order modelling for the simulation of braided stent deployment. Frontiers in physiology, 14, 1148540.

Camps, J., Lawson, B., Drovandi, C., Minchole, A., Wang, Z. J., Grau, V., ... & Rodriguez, B. (2021). Inference of ventricular activation properties from non-invasive electrocardiography. Medical Image Analysis, 73, 102143.

Fresca, S., Dede', L., & Manzoni, A. (2021). A comprehensive deep learning-based approach to reduced order modeling of nonlinear time-dependent parametrized PDEs. Journal of Scientific Computing, 87, 1-36.

Fresca, S., & Manzoni, A. (2022). POD-DL-ROM: Enhancing deep learning-based reduced order models for nonlinear parametrized PDEs by proper orthogonal decomposition. Computer Methods in Applied Mechanics and Engineering, 388, 114181.

de Chou, R. S., Sinclair, M., Lynch, S., Xiao, N., Najman, L., Vignon-clementel, I., & Talbot, H. (2024). Finite Volume Informed Graph Neural Network for Myocardial Perfusion Simulation. In Medical Imaging with Deep Learning.

Martonová, D., Peirlinck, M., Linka, K., Holzapfel, G. A., Leyendecker, S., & Kuhl, E. (2024). Automated model discovery for human cardiac tissue: Discovering the best model and parameters. Computer Methods in Applied Mechanics and Engineering, 428, 117078.

Nolte, D., & Bertoglio, C. (2022). Inverse problems in blood flow modeling: A review. International journal for numerical methods in biomedical engineering, 38(8), e3613.

Peirlinck, M., Linka, K., Hurtado, J. A., & Kuhl, E. (2024). On automated model discovery and a universal material subroutine for hyperelastic materials. Computer Methods in Applied Mechanics and Engineering, 418, 116534.

Vignon-Clementel, I. E., & Pant, S. (2022). Patient-specific Hemodynamic Simulations: Model Parameterization from Clinical Data to Enable Intervention Planning. Biological Flow in Large Vessels: Dialog Between Numerical Modeling and In Vitro/In Vivo Experiments, 139-161.

Figueres, the birthplace of Salvador Dalí and home to the Dalí Museum, is the capital of the Alt Empordà region which hosts the northern stretch of Costa Brava and the eastern most tip of the Spanish Pyrenees. Located 140 km north of Barcelona, Figureres is well connected by train (TGV, AVE), bus and priva-te car (Autopista AP-7) to Barcelona, Madrid, Lyon and Paris.