



Advanced Reduced Order Methods with Applications in Computational Fluid Dynamics

AROMA-CFD: ERC COG 2015 - GA 681447 - Panel PE1, Mathematics
FARE-X-AROMA-CFD - MIUR FARE; H2020 EID ROMSOC; H2020 RISE ARIA
PRIN NA-FROM-PDEs; EURO-HPC E-FLOWS4HPC; ERC PoC 2022 ARGOS

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Aims of AROMA-CFD, FARE, ROMSOC, ARIA, E-FLOWS4HPC NA_FROM_PDEs, and ARGOS

- To create a team of international scientists at SISSA for the development of Advanced Reduced Order Modelling intrusive and non-intrusive techniques with a focus in Computational Fluid Dynamics (CFD) for incompressible and compressible flows, also with turbulence.
- To face and overcome many current limitations of the state of the art and improve the capabilities of reduced order methodologies for more demanding applications in industrial, medical and applied sciences contexts.
- AROMA-CFD, FARE, ROMSOC, ARIA, E-FLOWS4HPC and ARGOS deal with strong methodological developments in numerical analysis, with special emphasis on mathematical modelling and an extensive exploitation of computational science and engineering as well as data science, machine learning and high performance computing.

Tasks in reduced order modelling developments

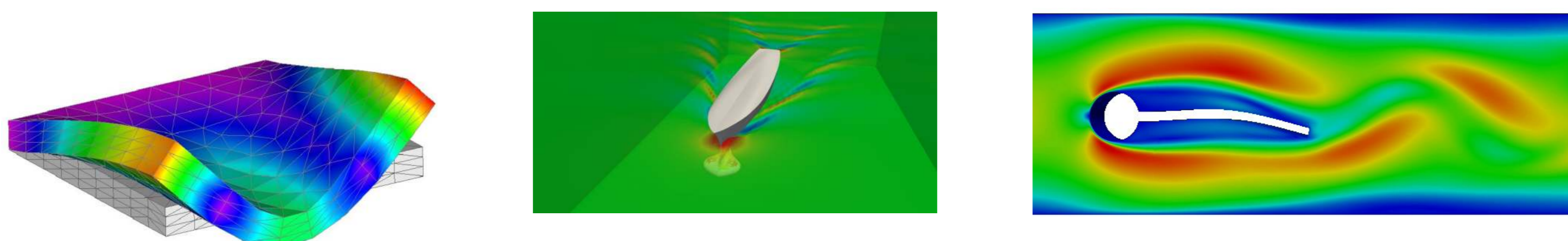
- Study of bifurcations and instabilities in mechanics.
- Increase Reynolds number while guaranteeing the flow stability.
- Move towards parametric turbulent flows.
- Consider complex geometrical parametrizations of shapes as computational domains, interfaces, as well as extended networks.
- Special focus on nonlinear inverse problems, focusing on optimal flow control, shape optimization, as well as uncertainty quantification.
- Multiphysics and multiphase flows.
- Reduction in parameter space.
- Machine Learning for advanced tasks (ANN, CNN, PINN)

Industrial Collaborations

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| <ul style="list-style-type: none"> Monte Carlo Yachts Fincantieri Danieli Danieli Automation SMACT Volkswagen Galdi | <ul style="list-style-type: none"> Arcelor Mittal Cetena Electrolux Professional Wartsila Alfa Romeo Sauber Orlen Dompè | <ul style="list-style-type: none"> Bormioli Pharma Optimad Micad Electrolux Lombardi Cergol |
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Applications in multiphysics

Advanced developments in reduced order modelling with CFD for applications in multiphysics and/or multiphase flows, including compressible flows and turbulence, fluid-structure interaction problems and more general coupled phenomena involving inviscid, viscous and thermal flows, solids and porous media.



National and International Collaborations

SISSA mathLab, MIT, University of Toronto, Houston, Harvard, Sevilla, Konstanz, Stuttgart, Ghent, Bordeaux, Santiago, Ulm, Muenster, Pavia, Trento, Milano, Trieste, Udine, Florida State University, RWTH Aachen, Sandia National Laboratories, Politecnico di Milano and Torino, TU Berlin, Brescia, IMT, Padova, Paris VI LJLL, ParisTech, EPFL, ETHZ, Imperial College, TU/Eindhoven, Amsterdam UVA, Sapienza Roma, Duke University, Virginia Tech, Singapore NUS, INRIA, Max Planck Magdeburg, Ospedale L. Sacco, Ospedale San Camillo, Sunnybrook Hospital, TU Wien, TU/Delft.

Rozza Group Research staff (2022)



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Industrial and medical applications

- Aeronautical, mechanical, naval, nautical, civil, off-shore, wind, sport, biomedical engineering with a focus on cardiovascular surgery applications.



- Towards real-time computing and visualization, through an offline-online computational paradigm combining high performance computing (in dedicated supercomputing centers) and advanced reduced order modelling techniques (in common devices such as tablets and smartphones).



Open Source Software Collection

New open source software libraries for AROMA-CFD are created: ITHACA galaxy (FV, SEM, DG) in real Time Highly Advanced Computational Applications, enhancing current RBniCS and multiphenics educational and training capabilities based on FEM. Other tools are developed in Python: PyGeM, PyDMD, EzyRB, BladeX, ATHENA, GRAPE, PINA. A computational web server is under development, ARGOS: argos.sissa.it, with its twin ATLAS. More info: <http://mathlab.sissa.it/cse-software>

