Spotlights in Computational Physics and Engineering (SCoPE)

Invited lectures on:

Introduction and recent advances in isogeometric reduced order methods

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Abstract

In a typical workflow for design and shape optimization, multiple simulations are required for different physical or geometrical configurations representing all possible designs. In particular for real-world, engineering applications this step can entail a high computational cost. The ability to represent and explore a large number of shape variations in a short amount of time calls for advanced computational techniques. Recently, this has motivated research efforts towards the development of an integrated framework from Computer Aided Design (CAD) to fast parametric simulation. The introduction of Isogeometric Analysis (IGA) allows for flexible geometric design and higher-order continuity in the analysis based on a single geometry representation for both design and analysis. To this end, the combined capabilities of IGA and reduced order methods is beneficial in the context of rapid simulations of parameterized geometries. In IGA, multi-patch and trimmed geometries are commonly used to represent complex shapes. However, shape variations introduce additional challenges for the application of reduced order methods to problems formulated on such geometries.

In this lecture, we will start with an overview of IGA and reduced order methods. Then, challenges and recent advances in the context of multi-patch geometries as well as efficient reduction of problems formulated on trimmed discretizations will be discussed. Finally, we will elaborate on the application of these methodologies to structural mechanics and optimization problems. The lecture is structured as follows:

1. Basic concepts related to spline basis functions, multi-patch geometries and trimming. Brief literature review and fundamentals on reduction techniques such as the reduced basis method, the proper orthogonal decomposition and the Greedy algorithm.
2. Recent developments in the context of multi-patch geometries. Presentation of advanced techniques that facilitate geometric variations and high-dimensional parameterizations such as the empirical interpolation method and domain decomposition strategies.
3. Challenges and recent progress related to the efficient reduction of problems formulated on trimmed geometries. Presentation of an efficient strategy based on localized reduced order models and clustering techniques.
4. Brief review of isogeometric Kirchhoff-Love shell analysis and coupling techniques for multi-patch trimmed geometries. Application of reduction techniques for fast parametric analysis and optimization in structural mechanics problems.

When and Where?

- 22.02.2024, 10:00-12:00, Maison du Savoir, MSA 3.070
- 23.02.2024, 10:00-12:00, Maison du Savoir, MSA 3.100

Invitee: Margarita Chasapi*

MARGARITA CHASAPI is a postdoctoral researcher at the Chair of Numerical Modelling and Simulation, **EPFL Lausanne** since 2021. Prior to that she obtained her PhD at **RWTH Aachen** University in Germany. Her research interests focus on isogeometric methods and model order reduction particularly in the context of structural mechanics.

Selected Publications

- M. Chasapi, P. Antolin, A. Buffa, A localized reduced basis approach for unfitted domain methods on parameterized geometries, Comput. Methods Appl. Mech. Engrg. 410 (2023) 115997.
- M. Chasapi, P. Antolin, A. Buffa, Fast parametric analysis of trimmed multi-patch isogeometric Kirchhoff-Love shell analysis using a local reduced basis method, arXiv (2023).
- M. Chasapi, P. Antolin, A. Buffa, Reduced order modelling of nonaffine problems on parameterized NURBS multipatch geometries, Lecture Notes in Computational Science and Engineering: RAMSES - Reduction, Approximation, Machine learning, Surrogates, Emulators and Simulators (2024).