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Carla Manni
Hendrik Speleers *Editors*

Geometric Challenges in Isogeometric Analysis

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Carla Manni · Hendrik Speleers
Editors

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Editors
Carla Manni
Department of Mathematics
University of Rome Tor Vergata
Rome, Italy

Hendrik Speleers
Department of Mathematics
University of Rome Tor Vergata
Rome, Italy

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Preface

The INdAM workshop "Geometric Challenges in Isogeometric Analysis" was held in Rome (Italy) from January 27 to 31, 2020. The workshop provided a discussion forum for researchers working in the area of isogeometric analysis and related fields, with a particular focus on the issues pertaining to the discretization of differential problems over complex geometries. The efficient and accurate description of complex geometries with tools that are appropriate for analysis (analysis-suitable) is one of the research fields of greatest interest for—but definitely not limited to—the isogeometric paradigm. Spaces of smooth (spline) functions on unstructured meshes, suitable for both geometric design and numerical simulation, are indispensable for isogeometric analysis to exploit its full potential for the treatment of complex real-life problems.

Thematic survey talks were complemented with talks presenting recent and innovative results on themes central to the scope of the workshop. The addressed topics include

- high-quality spline surfaces on complex and trimmed geometries,
- construction and analysis of smooth spline spaces on unstructured meshes,
- numerical aspects and benchmarking of isogeometric discretizations on unstructured meshes, meshing strategies, and software.

The present volume comprises a selection of fifteen contributions by several workshop participants and their collaborators.

The construction of smooth spline surfaces of any topological genus and of high quality on complex and trimmed geometries is the topic of the papers, "Quadrilateral Orbifold Splines" by Beccari and Prautzsch, "Trimmed Spline Surfaces with Accurate Boundary Control" by Martin and Reif, and "Subdivision and G-Spline Hybrid Constructions for High-Quality Geometric and Analysis-Suitable Surfaces" by Peters and Karčiauskas.

The two papers, "B-Symmetric Univariate Splines and Euler Numbers" by Boafo-Adade et al., and "Simplex-Splines on the Clough-Tocher Split with Arbitrary Smoothness" by Lyche et al., deal with structural properties of specific spline spaces. In particular, B-spline-like bases and Marsden-like identities are proposed for the Clough-Tocher split of any smoothness.

The set of papers, "DPB-Splines: The Decoupled Basis of Patchwork Splines" by Hemelmayr and Jüttler, "Completeness Characterization of Type-I Box Splines" by Villamizar et al., and "THU-Splines: Highly Localized Refinement on Smooth Unstructured Splines" by Wei, deal with certain hierarchical structures and their generalizations, with a special focus on their representation in terms of (truncated) hierachical B-spline bases, their completeness, and appropriate refinement strategies.

The papers, "A Collocation IGA-BEM for 3D Potential Problems on Unbounded Domains" by Falini et al., "Scattered Data Approximation by LR B-Spline Surfaces: A Study on Refinement Strategies for Efficient Approximation" by Skytt and Dokken, and "C^1 Triangular Isogeometric Analysis of the von Karman Equations" by Zareh and Qian, have a more applicative flavor. They present numerical experiments and discuss practical aspects related to applications of suitable spline spaces in different contexts ranging from isogeometric discretizations to approximation methods.

The pair of papers, "Fast Formation and Assembly of Isogeometric Galerkin Matrices for Trimmed Patches" by Marussig, and "A Block ILUT Smoother for Multipatch Geometries in Isogeometric Analysis" by Tielen et al., address the problems of efficient assembly of matrices arising from isogeometric methods and of design of appropriate solvers in the context of trimmed and multipatch geometries.

The interplay between meshing and bases as well as practical aspects of meshing are discussed in the two papers, "Meshing as the Choice of Basis Functions for Finite Element Analysis" by Sabin, and "HexGen and Hex2Spline: Poly-cube-Based Hexahedral Mesh Generation and Spline Modeling for Isogeometric Analysis Applications in LS-DYNA" by Yu et al.

We express our deepest gratitude to everyone who has contributed to the success of this workshop. We wish to thank all the speakers, as well as all the participants, for the interesting talks, the vivid scientific discussions, and the nice atmosphere during the week in Rome. This volume would not have been possible without the authors of the collected papers, who deserve our sincerest appreciation for their interesting works. Also, special thanks go to the anonymous referees for their precious collaboration.

Finally, we would like to thank INdAM for the principal financial support for the workshop organization, which also included the nice facilities in Rome. Additional support was received from the University of Rome Tor Vergata and its Department of Mathematics (MIUR Excellence Department Project 2018–2022).

Rome, Italy
June 2021

Carla Manni
Hendrik Speleers

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