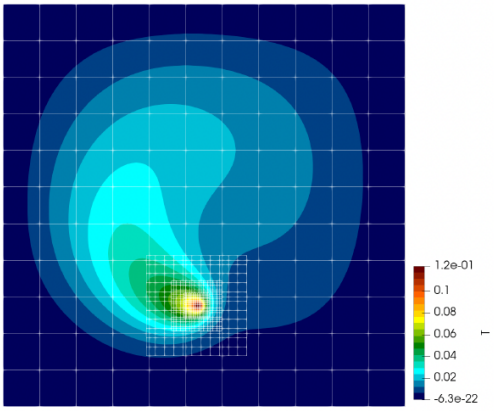
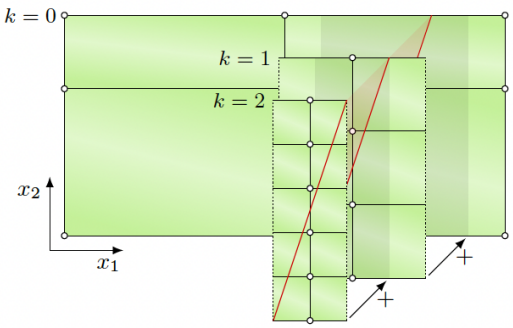
Space-Time Finite Element Simulation of Additive Manufacturing Using Unfitted Superposition Refinements

★★★★☆	Programming skills (JAVA)	Start:	immediately
★★★☆☆	Theory (non-linear FEM)	Duration:	6 months
★☆☆☆☆	Development	language:	English/German
★★★★★	Research		



a) Temperature field simulation



b) Unfitted Multi-Level *hp* concept

Motivation

Additive manufacturing has become a cornerstone of modern engineering, as it enables lightweight and highly efficient designs that are unattainable using conventional manufacturing techniques. The development, analysis, and optimization of such processes increasingly rely on advanced numerical simulation tools.

In this project, we seek to combine a space–time finite element formulation – where spatial and temporal dimensions are discretized simultaneously, thereby avoiding classical time-stepping schemes – with a novel local refinement strategy developed in-house. This approach, termed *Unfitted Multi-Level hp Refinement*, permits the superposition of multiple finite element meshes and thus offers a high degree of flexibility while circumventing the geometric restrictions inherent to traditional refinement techniques.

These capabilities are particularly advantageous for anisotropic refinements, which are of central importance in space-time finite element methods and are essential for resolving accurately the localized, directionally dependent features characteristic of additive manufacturing processes.

Scope of Work

- Review and critically assess the current state-of-the-art in (i) space-time finite element methods and (ii) numerical simulations for additive manufacturing.
- Become familiar with our in-house finite element framework implemented in Java.
- Develop and implement a space–time finite element formulation of the transient heat equation for one- and two-dimensional spatial domains.

- Validate the implementation by solving standard benchmark problems and assessing accuracy and convergence properties.
- Investigate a complex demonstration problem with relevance to real-world additive manufacturing applications.
- Prepare and typeset a scientific thesis or project report using LaTeX.

Our offer

- Regular meetings and continuous scientific supervision throughout the project.
- An introduction to cutting-edge research in numerical methods and scientific computing.
- Transparent and clearly defined grading and evaluation criteria.
- A research-oriented project with the potential to result in a scientific publication.
- Cooperation with a scientific project partner of Düsseldorf University of Applied Sciences

Kontakt

Numerische Mechanik (Prof. Dr.-Ing. habil. Martin Ruess)
e-mail: **martin.ruess@hs-duesseldorf.de**, **jan.schmaeke@hs-duesseldorf.de**