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Projection and Transfer Operators in Adaptive Isogeometric Analysis with Hierarchical B-Splines

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The finite element discretisation of a large class of boundary value problems requires highly refined meshes to appropriately resolve e.g. singularities in contact problems, shear bands in elasto-plasticity or steep local gradients in the field variables of phase-field models. If these domains evolve during the simulation, adaptive and local mesh refinement and coarsening are essential for efficient computations.

Isogeometric Analysis (IGA) introduced by Hughes et al. [1] overcomes the disjunction between geometry and computational models. Hence, IGA is the ideal discretisation technique to be combined with adaptive mesh refinement as already the coarsest mesh provides an exact geometry representation which is preserved during refinement. Tedious interactions with an underlying geometry during re-meshing, which is required to increase the accuracy of the geometry representation in standard FEM, are avoided.

We present projection methods and transfer operations required for adaptive mesh refinement/coarsening in problems with internal variables that possess own evolution equations at integration point level. By extending the results of Hennig et al. [2], we propose three different local and semi-local least squares projection methods for field variables and compare them to the standard global version. We discuss the application of two different transfer operators for internal variables. An alternative new operator inspired by superconvergent patch recovery [3] is also proposed.

The presented projection methods and transfer operations are tested in benchmark problems and applied to phase-field modelling of spinodal decomposition and brittle and ductile fracture.

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