Design of flexible data structures for handling Nitsche method in multi-region IGA

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ABSTRACT

While single region (single patch) IGA implementation does not look much more involved in comparison to FEM method, multi-region case is not so straightforward from implementation point of view. The main questions are: how to handle multi-region geometric model (especially in 3D) and how to "sew" solution on interface between patches.

In tackling the first problem we were restricted in our resources, thus we have decided to base the implementation on finite-element like decomposition of geometric model, using as implementation very comprehensive MOAB toolkit[1]. In other words the topology of decomposition of the geometric model is stored explicitly as MOAB mesh while all geometric data necessary for IGA are attached to mesh entities. The decision to use MOAB has saved us development effort with respect to handling entities adjacencies, enumeration, combinatorial operation on them, etc. This development was described in [2].

When attempting to redesign the simulator to handle Nitsche boundary conditions and possible link with FEM we have discovered that we need to take more abstract approach compared to storing the NURBS mappings and related dof data directly with MOAB data tags. The Nitsche method allows to substitute classical Dirichlet boundary conditions as well as solution continuity condition on region interfaces by specially prepared Neumann like terms. By this trick instead of dealing directly with degrees of freedom influencing the solution on regions interface in an approach resembling static condensation, one has to handle integrals over the interface. The terms under such integrals that come from patches adjacent to the interface can be handled separately. The first advantage is that discretisation densities for adjacent patches is now independent and the second is that the nature of degrees of freedom for the regions can be different, that is they can be IGA or FEM dofs.

In IGA one deals with parametric mapping for cells, that is the transformation from logical unit hyper cube into the actual cell geometry. By restricting the parameter domain one immediately can get the mapping for cell facet or edge. However for other discretisation method the availability of such restriction is questionable. This is our motivation to separately store the mappers for cells, facets and edges.

The choice of MOAB data structures as the basis for implementation and independent explicit storage of geometric mappers for different topological entities where in our opinion two key design decisions that lowered the cost of implementation and enhanced its flexibility.

REFERENCES

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