Higher-order immersed b-spline finite elements with sharp feature preservation

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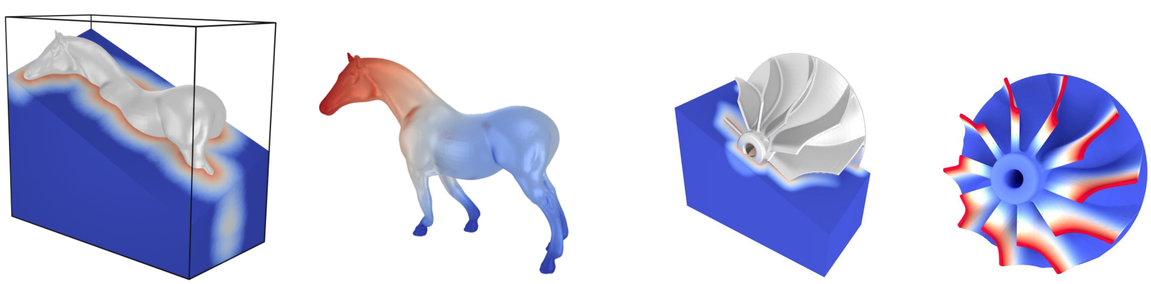
ABSTRACT

We present a higher-order immersed b-spline finite element technique with optimal convergence rates as an extension to our previous work on immersed finite element methods [1, 2]. Tensor-product b-splines and a non-boundary-conforming grid with cells of uniform size are used for discretisation. The Dirichlet boundary conditions are enforced with the Nitsche method. All the integrals appearing in the weak form are evaluated with sufficient accuracy so that optimal convergence rates are achieved. The cells intersected by the domain boundary are first tesselated using a marching tetrahedra algorithm and the linear tetrahedra are subsequently degree elevated and fitted to the curved boundary. The domain boundary is described with an implicit signed-distance function which is conducive for robust higher-order tesselation of cut-cells. Sharp features, such as edges in 3D and corners in 2D or 3D, are identified using the gradient of the zeroth level set and resolved with a novel bottom-up octree approach.

Although our tesselation algorithm is based on an implicit geometry description, we are able to consider parametric boundary descriptions, including subdivision surfaces and poor quality STL meshes from CAD kernels. For their implicitisation the signed-distance function is computed on a fine auxiliary tensor product grid (with up to 1000^3 cells) with linear basis functions. The boundary approximation errors are controlled by the ratio of the cell sizes of the auxiliary and computational simulation grids. The robustness and accuracy of the developed approach is demonstrated with a number of 2D and 3D examples.



REFERENCES

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[2] Rüberg, T. and Cirak, F. A fixed-grid b-spline finite element technique for fluid–structure interaction. *International Journal for Numerical Methods in Fluids* (2014) **74**:623–660.