Space-Time NURBS-Enhanced Finite Elements for Solving the Compressible Navier-Stokes Equations

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ABSTRACT

Geometries in engineering applications are commonly designed with the use of Computer-Aided-Design (CAD) tools. These tools typically utilize Non-Uniform Rational B-Splines (NURBS) to accurately represent complex geometries. Isogeometric analysis (IGA) [1] can directly be applied to such representations. The analysis of fluid flow, however, commonly involves complex three-dimensional flow domains. Parametrizing such domains by means of closed volume splines can be challenging and is still an ongoing topic in the IGA community.

An alternative approach was proposed in [2] and further extended for space-time finite elements and free-surface flows in [3]. This approach suggests to use standard finite elements in the interior of the domain, supplemented with so-called NURBS-enhanced finite elements along domain boundaries. These enhanced elements make use of NURBS to accurately represent complex geometries. This approach allows for maintaining the proven computational efficiency of standard finite element methods, while utilizing the accurate geometric representation provided by the NURBS-enhanced elements.

In the current work, we apply this approach to supersonic flow problems. For these type of problems, accurate geometric representation can be important, especially due to the presence of shock waves and their interaction with solid walls. For this purpose, the compressible Navier-Stokes equations are solved using a Stabilized Space-Time (SST) finite element formulation supplemented with NURBS-enhanced finite elements along domain boundaries. This apporach is demonstrated by means of a set of two-dimensional test cases and results are compared against solutions obtained with a standard finite element formulation.

REFERENCES

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