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A DISCONTINUOUS GALERKIN METHOD FOR COMPRESSIBLE FLOWS ON DEFORMABLE DOMAINS USING UNSTRUCTURED SPACE-TIME MESHES

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In this work, we study a high-order accurate discontinuous Galerkin (DG) method solving compressible flow with fully unstructured space-time meshes. The discretization of our space-time framework is based on a nodal DG formulation on the space-time domain, with appropriate numerical fluxes for the first and the second-order terms, respectively. The scheme is fully implicit, and we solve the resulting non-linear systems using a Newton-Krylov solver.

For each time step, we iteratively improve a triangular mesh using only node movements and element connectivity updates, and the corresponding space-time elements are produced directly based on these local operations. To obtain globally conforming tetrahedral meshes, we first derive the required conditions on a space-time prism mesh to allow for a valid local triangulation without inserting any additional nodes. Next, we present an efficient algorithm for finding a global mesh that satisfies these conditions. Finally, we also show how to add and remove mesh nodes, again using local constructs for the space-time mesh.

We demonstrate our framework on a model 2D problem of an inviscid Euler vortex, where we show that the scheme remains high-order accurate even for complex mesh reconfigurations. We also present three 2D laminar flow problems of a mixer with a rotating object, two pitching tandem airfoils, and an airfoil with a deploying spoiler, which show our method's capability to handle complex deformations.