A Second Order Unconditionally Positive Space-Time Residual Distribution Method for Solving Compressible Flows on Moving Meshes

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A space-time formulation for unsteady compressible flow computations in 2D moving geometries is presented. The governing equations in Arbitrary Lagrangian-Eulerian formulation (ALE) are discretized on two layers of prismatic space-time finite elements connecting levels n, $n + 1/2$ and $n + 1$. The solution is approximated with the linear variation in space (P1 triangle) combined with linear variation in time. The space-time residual from the lower layer of elements is distributed to the nodes in the level $n + 1/2$ with a limited variant of a positive first order scheme, ensuring monotonicity under a time-step restriction. The space-time residual from the upper layer of the elements is distributed to both levels $n + 1/2$ and $n + 1$, with a similar scheme, giving monotonicity without any time-step restriction, while the time marching procedure is achieved thanks to the first layer of elements. The scheme is positive and second order accurate in space and time for arbitrary meshes and it satisfies naturally the Geometric Conservation Law condition (GCL).

Example calculations are shown for the Euler equations of inviscid gas dynamics, including the 1D problem of gas compression under a moving piston and transonic flow around an oscillating NACA0012 airfoil.