Characteristic Interface Conditions for Multi-Block High-Order Computation on Singular Structured Grid

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Abstract

A structured grid with a body usually has a certain point where an abrupt change in the slope of grid line exists. The grid metrics are discontinuous at the point because of the discrepancy between the left- and the right-hand limits of the gradients, which leads to grid singularity. It may cause serious numerical oscillations especially when high-order finite difference schemes are applied to solving conservation-form governing equations in generalized coordinates. In this paper, it is handled by decomposing a computational domain into blocks along the singular lines and imposing interface conditions at the block interfaces for communication between the blocks. A set of high-order finite difference schemes is used in each block: central differences on the interior nodes and one-sided differences on the near-interface nodes. The differencing stencils do not cross the block interfaces and each block is isolated without the singularity, which results in no oscillations. For the communication between the isolated blocks, the interface conditions are newly derived from the characteristic relations of the compressible Euler or Navier-Stokes equations. The exactness and the feasibility of the interface conditions are investigated for the high-order multi-block computation on structured grid containing singular points.