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Vectorial limitation for multislope MUSCL schemes

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Among the numerical methods used in finite volume CFD codes to compute the convective fluxes, MUSCL schemes present the advantage to be second order accurate, while preserving monotonicity with a low computational time. Originally introduced for 1D scalar equations, they have since been extended to system of equations on multidimensional unstructured grids [1, 2] and are now used in many industrial CFD codes. The computation of a slope limiter function provides a second order accurate reconstruction for smooth solutions, and limits the reconstruction around discontinuities, hence avoiding numerical unphysical oscillations. This function can be computed once per cell (monoslope methods) or face per face (multislope methods).

One of the key aspects of these methods is how to adapt the interpolation and limitation process to the specific variables of the problem, which can be an issue also for higher order methods. For scalar cases, the process is already well established, but for systems of equations including vectorial quantities (such as the velocity), the task hasn't been much investigated. Usually, the vectorial interpolation method consists in interpolating and limiting the vector component-wise, but this approach doesn't lead to a frame-invariant method and can degrade the precision. Some methods have been designed to get frame-invariant vectorial reconstructions [3, 4], mainly designed for monoslope reconstructions.

In this talk, a new vector reconstruction for multislope MUSCL methods is introduced. Starting from the Total-Variation-Diminishing zone of a scalar variable in one dimension, we extend this zone for vectorial variables on multidimensionnal unstructured grids. This new method is frame invariant, preserves the monotonicity of the vector field in a specific sense, while improving the accuracy of the solutions, as illustrated by the numerical results presented on different test cases.

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