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Accuracy of WENO and Adaptive Order WENO Reconstructions for Solving Conservation Laws

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Weighted essentially non-oscillatory (WENO) schemes can be used to solve the equations governing transport in porous media. They are also useful in defining slope limiters for discontinuous Galerkin and other finite volume or finite difference methods. WENO reconstructions are a weighted average of polynomial approximations defined on various grid stencils. They are designed to produce high order accuracy on the big stencil when the solution is smooth and, when there is a shock, reduce to the order of the approximation on the smaller stencils. This was proven to be the case for the standard WENO reconstruction using the standard WENO-JS weighting procedure in 2011. In this talk, we analyze multilevel WENO reconstructions with adaptive order (WENO-AO) using both WENO-JS and WENO-Z weighting. WENO-AO is more flexible to implement in multiple dimensions and on unstructured computational meshes. We also present a new WENO-AO reconstruction. We give conditions under which the reconstructions achieve optimal order accuracy for both smooth solutions and solutions with shocks. The old WENO-AO reconstruction drops to a fixed, base level of approximation when there are shocks in the solution, but the new one maintains the accuracy of the largest stencil over which the solution is smooth. Our analysis in the discontinuous case requires that the smoothness indicators do not approach zero as the grid is refined. We provide a condition to ensure this result, but we also show an example where this can fail to occur. That is, we show that WENO reconstructions can fail to maintain the order of approximation of the smallest stencil over which the solution is smooth. We also present numerical results confirming the convergence theory of the old and new WENO-AO reconstructions, and compare their performance in solving conservation laws.

References

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