Application of Moving Adaptive Meshes in Hyperbolic Problems of Gas Dynamics

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It is well known that if the solution of flow equations has regions of high spatial activity, a standard fixed mesh technique is ineffective, since it should contain a very large number of mesh points. In case of hyperbolic problems of gas dynamics there are domains containing shock waves and contact discontinuities. A moving mesh adaptation algorithm is applied to reduce computational costs in practical modeling. In such an approach the grid nodes are relocated so that to increase mesh concentration in the domains of steep moving fronts, emerging steep layers, pulses and shock waves.

One of the adaptive mesh generation techniques is the variational approach based on the theory of harmonic mapping between surfaces and on the mesh cells convexity concept [1]. Approximation of the harmonic functional is build in such a way that its discrete counterpart has an infinite barrier on the boundary of the set of unfolded grids. The infinite barrier prevents the grid cells from degenerating that allows for generating unfolded grids both in any simply connected, including nonconvex, and multiply connected 2D domains. The barrier property is of particular importance in the vicinity of shock waves where the cells are very narrow and maximal aspect ratio attains 50 and larger [2]. When modeling 2D hyperbolic problems with discontinuous solution on the moving adaptive mesh it is possible to reduce the errors, caused by shocks smearing over the cells, by many factors of ten and therefore to decrease significantly, by several times [2], the total error throughout the flow domain.

Such a mesh adaptation requires to use a flow solver updating the flow parameters at the new time level directly on the moving grid without interpolation from one mesh to another, since interpolation smears discontinuities that, in turn, causes the accuracy of modeling to reduce. In the present work the Godunov Linear Flux Correction (GLFC) scheme, a finite-volume solver of the second order accuracy in time and space, is used to calculate the problems of ideal gas flow on the moving grids [2].

Coupled algorithm of using the GLFC scheme and adaptive moving mesh has been suggested in [4]. We present examples of using the coupled algorithm to model the 2D inviscid gas flow in 1D and 2D cases, having complicated wave structures.

References

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