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MOVING NODES ADAPTION COMBINED TO MESHLESS METHODS FOR SOLVING CFD OPTIMIZATION PROBLEMS

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Abstract. In past decades, many adaptive mesh schemes have been developed and become important tools for designers to simultaneously increase accuracy of their computations and reduce the cost of numerical computations in many engineering problems. In most of the cases the adaptation is done by subdividing cells or elements into finer cells or elements. Maintaining mesh quality during optimization procedure is still a critical constraint to satisfy for accurate design. In the discretized approach using meshless methods, there are no cells or elements but only a cloud of points which flexibility is an advantage compared to the mesh topology constraint. This attractive property facilitates the coupling of meshless methods with adaptive techniques for inverse or optimization problems.

In this paper, an algebraic adaptive meshless scheme based on a weighted reference radius equi distribution is presented. Cloud nodes adaption combined to meshless methods are used to solve inverse and drag minimization Computational Fluid Dynamics (CFD) problems.

The adaptive meshless method coupled with advanced Evolutionary Algorithms (EAs) is considered as a first test case to rebuild via prescribed surface pressure target the shape of the circular arc bump or ogive operating at supersonic shocked flow regimes. The objective functions could be chosen as the distance between candidate and prescribed pressure coefficients minimized in L_2 norm and uniform level of errors minimized in L_2 norm.

Then, a second optimization problem solved with cloud nodes adaption, namely the drag minimization of a natural laminar flow airfoil (RAE5243) operating at a Mach number 0.68 and a fixed lift coefficient 0.82 with an active shock control bump is conducted by controlling a uniformly distributed level of errors in the computational domain minimized using a sub-clouds and Nash game strategy. The two minimized objective are the shock drag satisfying a fixed lift constraint and the distance of the level of errors to a desired accuracy minimized in a L_2 norm.

Numerical results demonstrate numerically that adaptive meshless methodology presented in this paper can provide efficiently optimization solutions with a desired accuracy in aerodynamics. Results will be compared with other adaption methods, namely the so called goal oriented method.

SOME REFERENCES

[1] Nash, J. Non-cooperative games. The Annals of Mathematics, 1951, 2(54), 286-295.

[2] Tang, Z. L., Periaux, J., Dong. J. Constraints handling in Nash/adjoint optimization methods for multi-objective aerodynamic design. Journal of Computational Physics, 2012.

[3] Wang, H. Evolutionary design optimization with Nash games and hybridized mesh/meshless methods in computational fluid dynamics. Dissertation draft manuscript, University of Jyväskylä, 2012.

[4] Anguloa, A., Pozob, L. Pé. and Perazzo, F. A posteriori error estimator and an adaptive technique in meshless finite points method. Engineering Analysis with Boundary Elements, 2009, 33(11), 1322-1338.

[5] Qin, N., Zhu, Y. and Shaw, S. T. Numerical study of active shock control for transonic aerodynamics. International Journal of Numerical Methods Heat Fluid Flow, 2004, 14, 444-466.

[6] Hsu, A. T. and Lytle, J. K. A simple algebraic grid adaptation scheme with applications to two- and three-dimensional flow problems. AIAA Paper, 1989.

[7] Florentin, E. and Díez, P. Adaptive reduced basis strategy based on goal oriented error assessment for stochastic problems. Computer Methods in Applied Mechanics and Engineering, 2012, 225, 116-127.