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A semi-Lagrangean time-integration approach for fixed-grid based flow problems in the XFEM

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ABSTRACT

Many computational flow problems like combustion, two-phase flow or fluid-structure interaction incorporate discontinuities that evolve in time. The eXtendend Finite Element Method (XFEM) is able to represent discontinuities inside elements sharply by adding degrees of freedom in the vicinity of the interface.

We address the difficulties of formulating problems involving moving domains on fixed grids and point out that this is an important issue for problems with weak discontinuous fields and crucial for problems with strongly discontinuous fields. A method using semi-Lagrangean techniques is proposed to adequately handle time integration based on finite difference schemes in the context of the XFEM [1][2]. Previous solutions are adapted to the current interface location by tracking back virtual Lagrangean particles to their previous positions and thus extrapolating within a smooth field circumventing the discontinuity.

Convergence properties in time and space of the proposed method are thoroughly studied for one-dimensional model problems for strong and weak discontinuities including a comparison with other time-integration approaches.

Numerical examples are shown for premixed combustion, where a strong discontinuity separates the burnt from the unburnt gases, and for two-phase flow, where a weak discontinuity in the velocity field and either a weak discontinuity (without surface tension) or a strong discontinuity (with surface tension) in the pressure field is present between the two fluid fields.

REFERENCES

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