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Modelling and Numerical Simulation of Complex Fluids
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Lagrangian hydrodynamic, mixing modelling, anisotropic and topological mesh adaptation

Project proposed by

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Project and Aim

The general framework is the Lagrangian formalism on unstructured meshes where several fluids are present in the flow. It deals with the coupling of Euler equations of gas dynamics with turbulence.

The overall problem is the introduction of a second order turbulence mixture reduced model combining an elliptic term and hyperbolic kernel (reaction-diffusion with relaxation). The model is linear and depends on coefficients which are calculated in terms of the purely hydrodynamic (splitted) Lagrange-ALE step (on two-dimensional unstructured meshes). This problem requires considering a pressure tensor, a diffusion term which is proportional to this tensor and solving a system combining three linear PDEs per fluid.

When the cells are too distorted, the limit of the Lagrangian formalism requires the use of a rezoning process to adjust the grid (Arbitrary-Lagrangian-Eulerian). This step allows to obtain a better grid in order to improve the numerical precision on the approximation of the first order (hyperbolic) and second order (diffusion) operators.

The mesh adaptation is based on two treatments. The r-adaptation of the moving grid will be done by scalar weights and/or tensors, depending on the physics (velocity, concentrations and/or pressures). The h-adaptation (seldom in time loop) will also reflect the local nature of the flow, and a major point here is to determine the best topological cells in a zone to remesh. We emphasize that each new extensive unknown (such as density) needs to be defined in such a way that the overall process be conservative.

Summary

From a C++ code [6] where a polygonal ALE method (Lagrange + Rezoning + Remapping) is already implemented, eventually with non-conformal cells, we will address the three following *independent* problems:

1. **Hydrodynamics** [1,2,4]: introduction of a behaviour law (implementation from an algebraic closure and from the classical hydrodynamic multi-material equations).
2. **Diffusion** [5]: with isotropic and/or anisotropic coefficients, with a finite-volume method (here we should implement or use external libraries solving linear systems).

3. **Grid adaptation** [3]: anisotropic r-adaptation on polygonal meshes (implementation from an isotropic algorithm), h-adaptation by local determination of the optimal topology cells (implementation from a non-conformal or general polygonal description).

References

[1] Despres B. and Mazeran C., Lagrangian gas dynamics in two dimensions and Lagrangian systems, Archive for Rational Mechanics and Analysis, 178:327-372, 2005.
[2] Maire P.H., Abgrall R., Breil J., Ovadia J.,A cell-centered Lagrangian scheme for two-dimensional compressible flow problems, SIAM Journal on Scientific Computing, 29:1781-1824, 2007.
[3] Hoch P., Marchal S., Vasilenko Y., Feiz A.A., Non conformal adaptation and mesh smoothing for compressible Lagrangian fluid dynamics, ESAIM Proceedings, CEMRACS 2007.
[4] Speziale Ch.,
http://stinet.dtic.mil/cgi-bin/GetTRDoc?AD=ADA332772&Location=U2&doc=GetTRDoc.pdf
[5] Rebourcet B., http://www-troja.fjfi.cvut.cz/ multimat07/prezentace.html
[6] Benamou J.D., Hoch P., GO++ : A modular Lagrangian/Eulerian software for Hamilton-Jacobi equations of geometric optics type, ESAIM: Mathematical Modelling and Numerical Analysis, 36(5):883-905, 2002.