CS 5220: Project Proposal

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1 Background

The accurate representation of liquid-gas interfaces in CFD codes is paramount in performing low Weber number simulations. The research CFD code, NGA [1], used in Professor Olivier Desjardins' group at Cornell University, exactly conserves fluid mass, momentum, and kinetic energy while being formally second order accurate in space and time. In this code, two methods for interface tracking exist. One method, based on Owkes and Desjardins [2], uses the Lagrangian flux of liquid and gas volumes which are then geometrically cut by the computational cells and the liquid-gas interface. This method results in exact conservation of mass and second order curvature, however, is extremely computationally expensive to use. The other method, a conservative level-set method based on Desjardins et al. [3], moves a signed tanh function around the domain where the 0.5 iso-surface represents the interface. Since this amounts to little more than scalar transport, this method is much cheaper to perform, however the accuracy of this method relative to the Lagrangian flux based method is unproven.

2 Proposed Objective

The proposed project consists primarily of optimizing and tuning the Lagrangian based method for better performance, hopefully narrowing the gap between the two. NGA is already a highly parallelized code with excellent weak scaling characteristics, meaning improved performance is likely to come from improved serial methods, better handling of the subdomain information exchange between processors, the addition of dynamic load balancing, or porting the large number of simple cutting operations that must be performed to calculate the fluxes to a GPU or MIC chip.

3 Suggested Skill Set

NGA is a large (over 120,000 lines) CFD code written primarily in Fortran 90. For this reason, prior experience in CFD, scientific computing, and Fortran would most likely be a prerequisite for this project.

References

[1] O. Desjardins, G. Blanquart, G. Balarac, and H. Pitsch. High order conservative finite difference scheme for variable density low Mach number turbulent flows. *Journal of Comp. Phys.*, 2008.

[2] M. Owkes and O. Desjardins. A computational framework for conservative, three-dimensional, unsplit, geometric transport with application to the volume-of-fluid (vof) method. *Journal of Comp. Phys.*, 2014.

[3] V. Moreau O. Desjardins and H. Pitsch. An accurate conservative level set/ghost fluid method for simulating turbulent atomization. *Journal of Comp. Phys.*, 2008.