Chair of Aerodynamics and Fluid Mechanics
Department of Mechanical Engineering
Technical University of Munich

High-Fidelity Modeling of Two Phase Interfaces

Semester's Thesis, Master's Thesis

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Motivation

The left two images in figure 1 depict types of bubbles evolving in a denser (left) respectively lighter (right) fluid. Flows of air bubbles in water are two phase flows similar to the left image and common for many academic, industrial and natural environments or applications.

Studying two phase flows such as air bubbles in water is highly interesting and quite challenging due to the complexity of the interfacial physics. Only by means of high-fidelity numerical simulations the interface physics can be studied and knowledge gained.

High-fidelity modeling of these interface physics is ongoing research at the Chair of Aerodynamics and Fluid Mechanics, see e.g. [1–4]. The in-house CFD solver ALPACA incorporates state-of-the-art numerical models, algorithms and software design.

Objectives

The sharp interface method employed in ALPACA allows to precicely determine the interface position within the discrete fluid domain. In 2D it is even quite straightforward to determine the interface length within a two phase cell and the volume fractions of the two fluids. The interface length and volume fractions are necessary for computing the stresses acting on the two fluids and the interface. Yet, in 3D the interface area and volume fractions are more challenging to compute. Known from e.g. terrain modeling or computer vision the Delaunay triangulation serves as a fast and precise way to obtain the fluid-fluid interface area. It is the scope of this thesis to implement and evaluate a Delaunay triangulation algorithm for the interface area and volume fraction computation of two phase flows.

Requirements

- Interest in two phase flows
- Interest in computer graphics
- Experience with unix systems and the C++ programming language is helpful, but not required

What you learn during this thesis

- Deeper understanding in geometry reconstruction
- Insights into the simulation of complex flows with a state-of-the-art CFD code
- Working on modern HPC computing systems of the Leibniz-Rechenzentrum (LRZ)
- State-of-the-art software development

References

[1] Kaiser, J. W. J., Adami, S., and Adams, N. A. "Three-Dimensional Direct Numerical Simulation of Shock-Induced Bubble Collapse Near Gelatin". In: *11th International Symposium on Turbulence and Shear Flow Phenomena*. 2019.

[2] "Numerical Symmetry-Preserving Techniques for Low-Dissipation Shock-Capturing Schemes". In: *Computers & Fluids* 189 (2019), pp. 94–107. ISSN: 00457930. DOI: 10.1016/j.compfluid.2019.04.004.

[3] Schranner, F. S. "Weakly Compressible Models for Complex Flows". Dissertation. München: Technische Universität München, 2017.

[4] Winter, J. M., Kaiser, J. W. J., Adami, S., and Adams, N. A. "Numerical Investigation of 3D Drop-Breakup Mechanisms Using a Sharp Interface Level-Set Method". In: *11th International Symposium on Turbulence and Shear Flow Phenomena*. 2019.

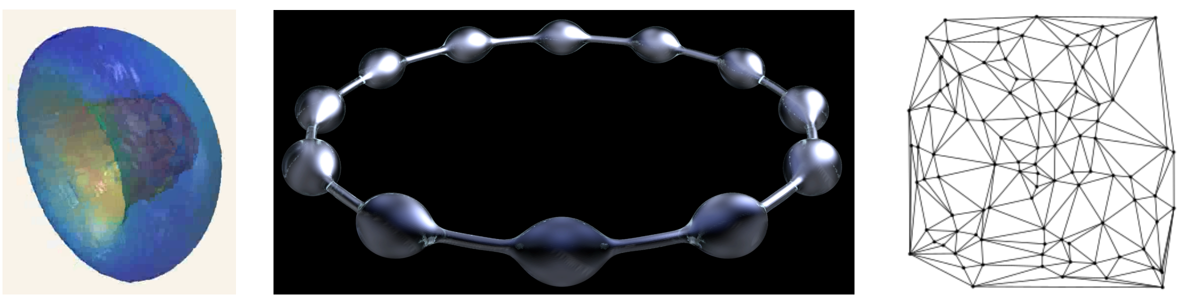

Figure 1: Bubble evolution scenarios and Delaunay triangulation of a set of points