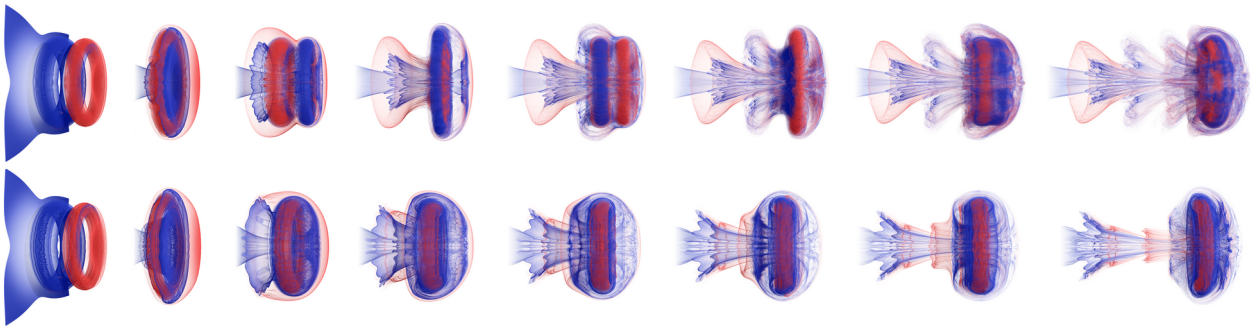
An Advection-Reflection Solver for Detail-Preserving Fluid Simulation

This project aims for an advanced smoke animation solver that uses the advection-reflection method. This requires essential programming/software skills for generating computer animations and thorough understanding of numerical simulation of partial differential equations, in particular, the Navier-Stokes equations that model a variety of fluid flows. You are expected to perform autonomous study and research how to generate smoke animations using computer.



Objectives

The first step is to understand the fundamental knowledge of grid-based fluid simulation pipeline, which needs a linear system solver such as the conjugate gradient method [1]. You will start with implementing a two-dimensional smoke simulator and then continue to a three-dimensional one. You can integrate an open-source library, e.g., Eigen[1], to solve the linear system. However, you have to implement yourselves the core of the advection-reflection solver [2]. The simulation output will be a sequence of grid data representing temporal and spatial changes of smoke density (and velocity). Thus, you also have to visualize the density data using a rendering software such as Blender[2] or Mituba[3]. A framework having these (simulation and rendering) modules is the outcome of this topic. Once achieving, it is strongly encouraged to improve the pipeline with own ideas, e.g., speeding up each module via multiprocessing, adding another solver, changing rendering setups, etc.

Topic difficulty: ☐ *easy* | ☐ *intermediate* | ■ *advanced*

Prerequisites

- Good programming skill in C/C++ both for implementing new codes and utilizing existing codes
- Knowledge of numerical simulation
- Experience of computer graphics libraries/tools or interest in using them

References

[1] 1994, Shewchuk, An Introduction to the Conjugate Gradient Method Without the Agonizing Pain

[2] 2018, Zehnder et al., An Advection-Reflection Solver for Detail-Preserving Fluid Simulation, ACM Trans. Graph.

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1 http://eigen.tuxfamily.org/
2 https://www.blender.org/
3 https://www.mitsuba-renderer.org/