RIPS 2014 Disney Project Description

Preconditioning of the Poisson equation using the domain decomposition method

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1 Background

Physics-based simulation is a key component to modern special effects and the creation of realistic visual environments. One of the more impressive of these phenomena is fluids. Incompressible flow is used to model a wide range of natural phenomena, including water, smoke, fire, and air.

2 Description

The students will experiment with simulating fluids using a FLIP (Fluid implicit particle) approach [2], the core part of which is a pressure Poisson solve. Poisson equations are notorious for having poor conditioning and are difficult to solve in practical settings without effective preconditioners. The students will investigate preconditioning of the Poisson equation using the domain decomposition method [1].

3 Objectives

We will be using an existing FLIP solver (2D and/or 3D versions), implemented using C++ programming language. Thus, all the necessary algorithms for fluid simulation and visualization of the results will already be supported. The students will be primarily dealing with the Poisson projection part of the fluid solver. In particular, they will investigate the use of the domain decomposition method to improve its convergence behavior. The method's convergence properties for a particular Poisson matrix can be investigated using MATLAB, which would be a good starting point. We then plan to proceed with C++ implementation of the preconditioner in order to test it in the actual simulation environment. If time permits we would also like to investigate the applicability of the approach to *compressible* FLIP.

4 Deliverables

1. Software: C++ and MATLAB code
2. Experimental results: convergence/timing plots and videos
3. A written report outlining methods used and results
4. A presentation

References

[1] A. Toselli and O. Widlund. *Domain Decomposition Methods - Algorithms and Theory*. Springer Series in Computational Mathematics. Springer, 2005.

[2] Y. Zhu and R. Bridson. Animating sand as a fluid. *ACM Trans. on Graph.*, 24(3):965–972, 2005.