Realtime Computational Fluid Dynamics Simulations using the Lattice Boltzmann Method
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Abstract

Fluid simulations are useful in many different areas ranging from weather modelling to microscopic physics. Using the conventional method of solving the districtized Navier-Stokes equations is very computationally intensive and relatively hard to parallelize. The lattice boltzmann method instead uses the discrete Boltzmann equation to simulate Newtonian fluids using various collision models.

Keywords: computational fluid dynamics, lattice boltzmann methods

1 Introduction

The purpose of this project is to accelerate relatively new methods in the field of computational fluid dynamics in order to be able to run realtime simulations. This includes using new methods that can be parallelized more effectively and vectorizing these methods and running them on new hardware using GPGPU techniques.

2 Background

Background research that is needed for this project includes a sophisticated knowledge of physics. I need to learn about topics including the Boltzmann equation, collision operators such as the BGK collision operator. I also will need to learn more about MPI and GPGPU programming techniques such as OpenCL.

3 Procedure

The first steps of this project are learning the physics behind the boltzmann equation and various collision operators. Then, I have to learn how the boltzmann equation is districtized into a lattice. Then, I will code a 1 dimensional simulation in either C or ruby in order to get a basic simulation working. Then, I will expand it into 2 dimensions and start work on parallelizing and making sure it is working correctly.

4 Expected Results

The project will be expected to yield a CFD code that is able to simulate fluids in realtime. This can be used in realtime predictions in various fields, for example control systems dealing with fluids. The speedup techniques used can also be applied to make larger simulations run faster.

References

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