Methods of Simulating Fluid Motion in a Shallow Context in 3-Dimensions

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Abstract

As computer graphics become more advanced and realistic, it becomes necessary to learn how to recreate real-life events in a virtual environment. The events that have proved most problematic in this regard are those that occur in nature. In this project I will investigate techniques to automate simple, shallow fluid motion found in everyday life.

Keywords: Computational Fluid Dynamics, Computer Graphics, OpenGL, Navier-Stokes, Saint Venant

1 Introduction

1.1 Background

Computer graphics have found many uses nowadays. It's used for animated movies, video games, and simulation software. As technology has progressed over the last few years, however, the quality of this graphic design has been increased dramatically. Photorealistic animations are now commonplace. However, it is no longer enough to merely look realistic, they must now act realistic as well. Recreation of the motion of fluids has proved to be an enduring conundrum for graphic designers.

1.2 Obstacles

There are a number of factors that have made it difficult to recreate fluid motion. Graphic modeling is usually performed by creating a large set of 3-Dimensional objects. This makes representing solids that do not change readily very simple, but makes creating fluids, which are continuous entities that are constantly changing, quite difficult. A deep understanding of physics is also required to recreate the motion of fluids as they are dictated by a large set of rules in nature. Because there are countless different situations and conditions that occur in nature, accounting for all of these possiblities has made it hard to code realistic fluid motion.

1.3 Objectives

There has been a great deal of research into the field of fluid dynamics and the rules that govern fluids. Our objective is to determine how these rules can be applied in a simulated environment. Because this is a very broad field of study, this research will focus only on liquid fluids in small, standing, and shallow contexts. This way we can isolate only a few variables to be concerned with. In doing this, we can ignore the factors of flow and currents, like those found in rivers and oceans, making the scope of the project more specified.

2 Related Work

The field of fluid dynamics is not limited to only liquids, and others have performed research regarding the flow of air and other gases [3]. This sort of project has a number of uses in areas such as aerodynamics and wind tunnel simulations.

3 Problem to Solve

3.1 Fluid Representation

Before even thinking about any fluid dynamics equations, we must first consider how to represent the fluid in a computer generated environment. In the case of liquids, one of the most popular options is to use a particle system, in which each particle represents one water molecule and acts independtly of the others. Another, similar method is to create a large 3-Dimensional grid and have each cell act as a small section of the body of water. These methods are very intensive on computer resources, as they require calculations for a very large number of different objects. These will not be used in this project, as they are far too complicated for our needs. Instead we will use what is called a hight field. A height field is a 2-Dimensional matrix of points that represent points on the surface of our liquid body. This field is displayed on the XY-plane to the viewer, and each point in the grid has a height value, which is then reflected on the Z-axis. This method is the most reasonable for our purposes, as our shallow body of water is not concerned with the flow of water below the surface.

3.2 Computational Fluid Dynamics

After deciding on how to represent liquid in 3-D space, we must then figure out how to make it move. The most common method is the use of the Navier-Stokes equations, discovered in the 19th century. These equations take into account variables such as pressure, gravity, viscosity, and density to describe velocity vectors for every point in a body of liquid. This equation is applied in many different ways depending on the context and often combined with other mathematical ideas. Because our situation only concerns a shallow body of water and thus we only care about its motion on the surface, the Navier-Stokes equation can be simplified to disregard the depth of the water. Our program will use this equation and apply it to every point in the height matrix which will in turn resolve that point's height and display it accordingly.

4 Conclusion

In this paper we have described the most often used methods of simulating fluids in any computer generated context. We have also worked on our own project and resolved how to emulate motion in shallow bodies of water.

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