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 Research

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. This is because all computer graphics are based on the combined use of many 3-Dimensional objects. This makes modeling solids very simple, but very difficult when it comes to fluids. 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, encompassing all of these possiblities has made it hard to code realistic fluid motion. Several different methods to approaching this problem have been researched in this field. The Navier-Stokes equations, first proposed in 1822 provide a way of understanding motion in incompressible fluids. The Saint Venant equations are also used, and these are based on the Navier-Stokes equations but applied in a context that does not compensate for depth.

2 Goal

The goal of this project is to create a program that can model the motion, such as ripples and waves, of a small, shallow body of water when disturbed in three dimensions.

3 Design Criteria

There will be several elements that I will incorporate into my project. The first will obviously be the window displaying the current 3-Dimensional model. I will also incorporate mouse and keyboard inputs to controls things such as the view and orientation of the model and the zooming in and out of it. In addition, several menus will be used to control key variables in the project. Light effects will be added and reflection and refraction of that light is planned.

4 Procedure and Scope

In order to understand the physics behind this project, I will continue to do in depth research into what has already been learned by others about the subject and I will also discuss it with the resident physics teachers at Thomas Jefferson. I will most likely also have to do my own hands-on research on the subject of waves. I will then, from this research, discern the best way to model this motion in the form of mathematical equations and use them to manipulate the 3-D models in my program. Because of the complexity of the general subject area, this project will only focus itself on shallow contexts and not try to recreate currents or large bodies of water.

5 Expected Results

The goal of this project is a very ambitious one, so while I do have high hopes for this project, I am uncertain of it's feasibility. My measure of success will be if I can have a running simulation program that accepts all appropriate inputs and shows a basic system of using these inputs in the changing of its modeling of fluids. I will most definitely need all the time I can get for working on this project to complete it. If a student next year would like to continue in the same direction as I, I would suggest the modeling of currents such as those found in rivers and oceans.