TJHSST Computer Systems Lab Senior Research Project
An Interactive, User-driven Physics Simulator
2007-2008

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November 2, 2007

Abstract

Physics simulations are often of single concepts or immune to user control. My project aims to change that by allowing users to create a situation and then simulating the behavior of objects in that situation. Users will create objects either by freehand drawing or shape tools, then the program will convert them to polymorphic objects and run the simulation. Objects varying from the simple to complex will be modeled: single shapes or multiple shapes connected statically or with axles.

Keywords: physics, simulation, interactive, ASSIST

1 Introduction

The majority of my research was in physics simulation: how to do it accurately, what equations to use, and how to implement them. I can follow my original idea of having users draw systems freehand rather than using predetermined shape tools; if I do the former I will have to research computer vision to identify objects. Using the equations and properties that I give objects, the program should determine and show the way that the objects will behave. I will start with basic equations and add more complex ones as the year progresses.

This project should be able to model projectile motion and interaction between simple and complex objects. I define simple objects as single rectangles or ellipses, and complex objects as multiple rectangles and ellipses connected by pins or axles. Interactions include collisions, friction, and objects resting or rolling on other objects.

My goal is to create a program which anyone can use to gain a better understanding of physical interactions by inputting any situation and seeing how objects behave. I will also come to understand physics better by implementing all of the equations and interactions.

2 Background

A team from MIT created ASSIST: A Shrewd Sketch Interpretation and Simulation Tool which inspired this project. The program was created in order to give engineers a way to model systems in the early stages of design,

when only an idea exists, before a traditional CAD program, which requires precision and planning, would be appropriate. The user draws a mechanical system on a smartboard, including an arrow for gravity. The "sketchpad" system then interprets the drawing. Certain symbols have special meanings: an x is an anchor, a small circle is a pivot. Finally, the interpreted drawing is fed into a commercial simulator.

My project aims to be similar to ASSIST, but with more focus on the physics. Also, whereas ASSIST simply cleans up the user-drawn images, my project would guess what the user wanted to draw, and replace, for example, a lopsided rectangle with a more regular one.

3 Testing and Analysis

I may be able to graph position, velocity, and acceleration functions to determine how accurately the simulation runs. However, most testing should consist simply of looking at whether or not the simulation behaves as expected. For example, it is apparent that there is a problem when two objects of equal mass collide elastically but do not trade velocities. I can also use process modeling - comparing the data of an object to the data predicted by equations - over short time periods to determine if the objects act as real objects would. In the previous example, I outputted the positions and velocities of objects before, during, and after the collision in order to determine where the problem was.