TJHSST Computer Systems Lab Senior Research Project
An Interactive, User-driven Physics Simulator
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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 - Elaboration on the problem statement, purpose, and project scope

1.1 Scope of Study

The majority of my research will be in physics simulation: how to do it accurately, what equations to use, and how to implement them. If I follow my original idea of having users draw systems freehand rather than using predetermined shape tools, I will have to research computer vision to identify

objects. Using the equations and properties that I give objects, the program should determine and display the way that the objects will behave. I will start with basic equations and add more complex ones as the year progresses.

1.2 Expected results

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.

With this simulator I hope to provide a program which anyone can use to gain a better understanding of physical interactions by inputting any situation and seeing the results of it. By implementing all of the equations and properties, I should also come to a greater understanding of physics.

1.3 Type of research

My project is use-inspired basic research: it will allow me and others to understand physical interactions, but because it is a simulator, it will also be usable for modeling purposes.

2 Background and review of current literature and research

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   Procedures and Methodology

In the first half of the second quarter I hope to have completed projectile motion, collisions, friction, and rotation. After that I can begin working on a new, easier method of user input. Once that is complete I will implement complex objects. I will be able to find equations and other simulations on the internet, but it may help to borrow one of the school's physics books. I will be doing all of my programming in Java 6.

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. I can also use process modeling over short time periods to determine if the objects act as real objects would.

4   Expected Results

Once my project is completed, I will have other people create their own situations and let them see how my program simulates them. Some situations should be simple enough that the result should be intuitive, while others will be much more complicated and the users will determine while the program is running whether or not the results look accurate.