Rigid Body Dynamics: A Graphical Simulation

Eugene Paik
TJHSST
Alexandria, Virginia

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Abstract

Dynamics is the study of the interaction between different bodies based on the laws of physics. The possible implications of a computer simulation in which dynamics are simulated are endless. A working dynamics simulation would be useful to engineers who are interested in designing a building, students trying to grasp the law of conservation of momentum, or even video game programmers who want their games to be as realistic as possible. The goal of this project is to design and program a fully functional, efficient, rigid-body dynamics simulation capable of supporting objects of variablei shape and mass. Because of the consistencies between two-dimensional and three-dimensional dynamics, this project will be focused on only the two-dimensional aspect for the sake of simplicity.

Keywords: rigid body dynamics, physics, simulation, graphics

1 Introduction

The scope of this project will be divided into two areas, the math behind dynamics, and the graphics and interface of the simulation itself. While I have a basic understanding of physics in general, the greatest difficulty in programming this simulation will probably be collision response. When two bodies collide, the resulting normal force acts on both the linear and angular

aspects of the bodies. The graphics and interface should be very simple and intuitive, allowing the user to create, delete, and move bodies throughout the world. The end result of this project will be a fully functional two-dimensional simulation of many convex two-dimensional rigid bodies in a world that the user can interact with. This simulation will help the user understand how such bodies might act in real life. Ultimately, the project will examine different methods in which masses can be efficiently simulated. Through this project, I hope to garner a better understanding of dynamics in general. I chose this area of research because I am especially interested in the role of dynamics in the gaming industry. The central focus of this project is to discover a new method of simulating dynamics that will aid future programmers in their applications of dynamics. This project will be purely applied research, I will be programming a working rigid-body simulation before trying to explore any new areas of research.

2 Background

In today's society, dynamics is still being researched and developed by scientists. When researching simular projects to mine, I have come accross applications of dynamics in areas such as animation and game design. One particular set of articles of interest by Pixar Studios covers all of the elemntary aspects of physically based modelling required to animate realistic characters in film. There are also various papers online that cover small areas of collision detection, collision response, or physics. Most researchers focus on only a small area of dynamics, such as friction or fluid dynamics. In contrast, my project will be approaching a much broader area of research, drawing on these other works for information.

3 Testing and Analysis

The first phase of this project after doing research is design. A modular framework would be very useful because of the applications of many different bodies in dynamics. This framework would have to be designed and programmed before anything could be implemented. After this framework is finished, the two bodies that I would focus on implementing would be the box and circle. These bodies are the most commonly simulated bod-

ies, and as a result should be completed first. I will be using Java and the Graphics2D library to program the simulation. The visuals of this project would be entirely based on the image produced while the simulation is running, along with some side-information that may be passed to the console for debugging purposes. The testing phase will be heavily interlaced with the development/programming phase, as I debug and fix code as I go along. Various tests will be observed such as bodies with random positions with random forces acting on them interacting with each other. To validate how well the program simulates dynamics, similar tests may be conducted in real life and compared to the tests in the simulation.