Extensible Simulation of Planets and Comets

Natalie Wiser-Orozco
Department of Computer Science
and Engineering
CSU San Bernardino
San Bernardinio, California 92407-2393
Email: natalie@otsegoville.com

Keith Schubert
Department of Computer Science
and Engineering
CSU San Bernardino
San Bernardinio, California 92407-2393
Email: schubert@csci.csusb.edu

Ernesto Gomez
Department of Computer Science
and Engineering
CSU San Bernardino
San Bernardinio, California 92407-2393
Email: egomez@csci.csusb.edu

Richard Botting
Department of Computer Science
and Engineering
CSU San Bernardino
San Bernardinio, California 92407-2393
Email: rbotting@csusb.edu

***Abstract*—The research conducted is intended to enhance the way we view and study our solar system and others, by allowing scientists of astronomy, physics, and computer science to accurately simulate an arbitrary number of celestial systems. The Extensible Simulator organizes the celestial bodies to be studied into groups, calculates their positions, graphically visualizes their movement using the computed positions, and finally, is extensible, which serves to accommodate additional numerical methods and gravitational functions, body shapes and behaviors, and camera views.**

I. Introduction

We have great interest in the ability to simulate not only our own solar system, but also other solar systems, because it may mean that we will be able to avoid disaster, or determine if a newly discovered solar system is stable. Using ordinary differential equation(ODE) solvers, Sir Isaac Newton's Law of Universal Gravitation modified for n-bodies, we can accurately simulate a graphical rendering of a system. The framework developed not only allows for the aforementioned graphical simulation of an arbitrary number systems, but also allows extensibility of the simulator itself. Different bodies, cameras, numeric methods, and gravitational functions can be integrated easily with the Application Programming Interface(API), allowing the simulator to adapt to the growing needs of professionals in the relevant fields.

II. Background

The two major driving forces behind the Extensible Simulator are the gravitational function used, and the method of solving the gravitational function. In the 15th century, Johannes Kepler concluded that the orbits of planets were ellipses. Later, using Kepler's third law stating the inverse square relationship between orbital period and the length of the semi-major axis, Newton derives his Law of Universal Gravitation. Extending this to accommodate n-bodies, the equation used is as follows:

$$\ddot{\mathbf{r}}_i = -G \sum_{j=1, j\neq i}^{j=N} \frac{m_j(\mathbf{r}_i - \mathbf{r}_j)}{|\mathbf{r}_i - \mathbf{r}_j|^3} \qquad (1)$$

We use a numeric approach as a means of solving this this second order ODE, which allows us to arrive at approximate yet accurate values for the trajectories of the planets. The particular numeric method used is the Runge-Kutta Fourth Order method.

III. Extensible Simulator

The Extensible Simulator allows users to organize systems into "projects", where they can construct the definitions of the bodies to be simulated. Allowing the selection of the gravitational function and numeric method allows for flexibility, arriving at the most accurate results possible. A graphical simulation using the calculated trajectories is made available, with its purpose being ease of communication between peers and the public.

In addition to the above features, an API is included, which allows the extension of Camera and Body base classes that can incorporate new features of each. New scripts implementing different ODE solvers and gravitational functions can be easily added as well.

IV. Conclusions and Future Work

A framework has been laid for analyzing our solar system and others, which provides accurate calculations of body trajectories using the Runge-Kutta Fourth Order method, and the n-body gravitational function. Future work may include extending base classes in the API to accommodate different shapes, colors, and textures of bodies, different camera paths and scene navigation, adding variations of gravitational functions, and other numerical methods that may be able to accommodate the often large differences between orbital periods.