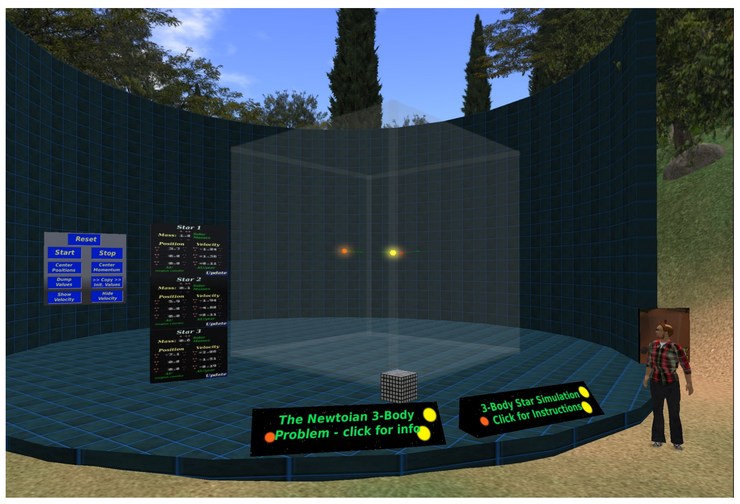
Visualization of N-body Simulations in Virtual Worlds

Knop, R (MICA), Ames, J (Genkii), Djorgovski, G (Caltech), Farr, W (Northwestern), Hut, P (IAS), Johnson, A (Genkii), McMillan, S (Drexel), Nakasone, A (Nat'l Inst. of Informatics, Japan), Vesperini, E (Drexel)

The 3-Body Problem in Second Life



What is Second Life?

Second Life™ (SL) is an online virtual world. Although it bears superficial similarity to massive multiplayer online games, it is rather a tool that may be used for many things, including immersive online collaboration.

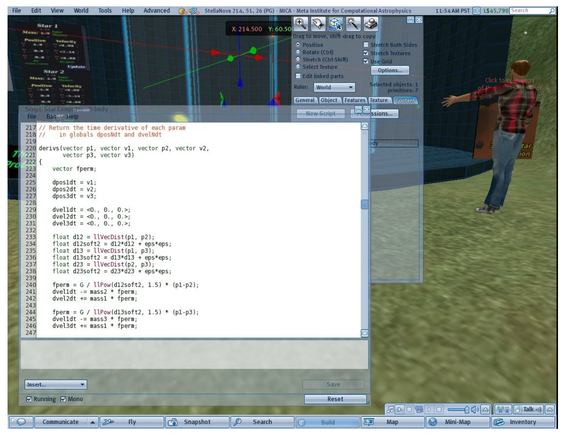
A Second Life account is free; http://secondlife.com

SL is supported on Linux, MacOS, and Windows. It will perform better with a recent ATI or NVidia 3d graphics card with dedicated video memory.

The Linden Scripting Language

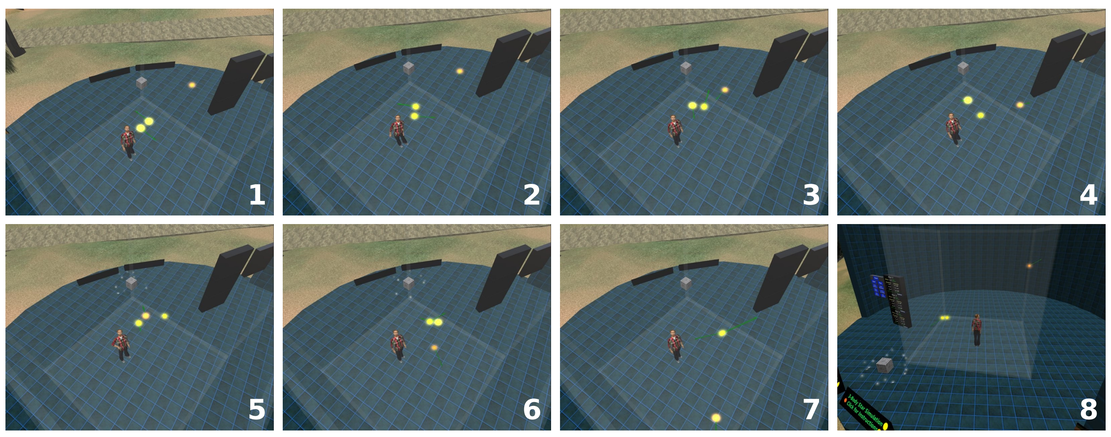
Most of the content was built by the users using the built-in 3d modeling tools. You can assign behaviors to objects you've built by writing scripts. LSL is a simple (but limited!) procedural language superficially similar to C, with an API that allows interaction with scripted objects.

LSL is a limited language (it doesn't have arrays), and runs slowly. However, it has a powerful set of functions for controlling the SL environment.



On the Web : http://www.manybody.org/wiki/index.php/LSL_3-Body

In-World : http://slurl.com/secondlife/StellaNova/205/50/26



A sample 3-body simulation: the simulation uses the 4th-order Runge-Kutte integrator. It solves on a fixed time step, and commands stars to move around as the solution is being calculated. As LSL doesn't have arrays, all loops are unrolled. In this sample calculation, a $2M_\odot$ circular binary is visited by a $0.6M_\odot$ interloper. The stars dance, a tight binary is formed, and one star is ejected.

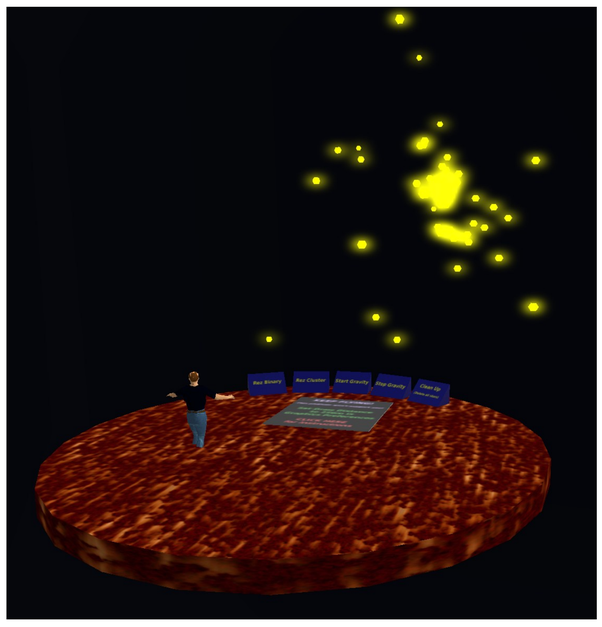
The N-Body Problem in OpenSim

What is OpenSim?

OpenSim is a 3D applications platform. It started as a virtual world server using the same protocols as SL so that the open source SL viewer could connect to it. Because it's open source, anybody can download it and extend it using a powerful modern computer language (C#). What's more, OpenSim aims to provide an API so that others may build applications on top of it. While still in the alpha stage with an API subject to further changes, it promises to be much more than an “open source SL clone”.

There are several grids out there running OpenSim, including OSGrid and ScienceSim. You can connect to OpenSim grids using the same viewer software used to connect to Second Life.

For more information, go to http://www.opensimulator.org



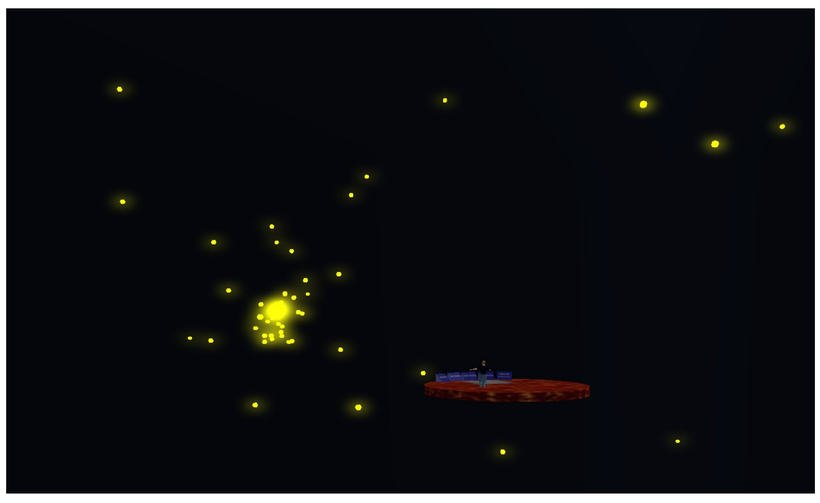
A cluster simulation with 64 stars runs in the MICA StarSim region on ScienceSim, observed by an avatar in front of control panels.

The NewtonPlugin OpenSim Physics Engine

By default, OpenSim uses the OpenDynamics Engine (http://ode.org) to simulate collisions between objects and avatars. Because OpenSim is open source, we were able to replace the physics engine with an N-body solver. The NewtonPlugin engine treats all objects marked as physical as gravitating particles, and updates their positions and velocities based on their mutual gravitational interaction using a direct N-body code. The result is an N-body calculation performed not by a script, but by the server itself. It's useful for demonstrations, and works with small N (<100) on modest hardware. The code has several integrators implemented. The simulation shown in the screen shots comes from a run with a simple first-order Forward Euler integrator.

You can find this engine running in the “MICA StarSim” region on ScienceSim. You can also download it and run a standalone instance of OpenSim on your laptop or desktop.

On the Web : http://www.manybody.org/wiki/index.php/NewtonPhysics



ScienceSim

ScienceSim is an OpenSim grid originally supported by Intel for the Supercomputing 2009 conference. It is trying to become a foundation that will produce a stable distribution of OpenSim. The grid focuses on education and research uses. To connect, visit http://sciencesim.com

The Future: Visualization of External Data

Both of the projects described above are great for demonstration and outreach purposes. While solving the 3-body problem in LSL is equivalent to 1970's computational science, Second Life is where the people are. It gives us an opportunity to let visitors play with a real astrophysical computation. The NewtonPhysics engine demonstrates the additional power you have when you have access to the server software itself, and should allow for richer educational demonstrations.

The future of virtual worlds in scientific research will be using this new technology to visualize external data. Some experiments have been done with this already, including Arturo Nakasone's AstroSim (which uses a software-controlled SL user account to import the data), and Crista Lopes' StellarSim plugin for OpenSim. Ultimately, it does not make sense to run your simulations on the same hardware that is busy doing the calculations to provide the virtual world server.

Three spatial dimensions plus time is the maximum amount of information the human brain can easily handle, and the immersive nature of virtual words provides an ideal platform to visualize data on commodity hardware. Astronomers and others associated with MICA will be doing further work in studying and implementing tools that will allow both visualization of external datasets, and interactive visualization and control of simulations running on other computers or clusters.

Why Virtual Worlds?

Why use virtual worlds to visualize the results of N-body simulations rather than a desktop package that doesn't have the overhead of connecting to a server? The primary reason is for remote collaboration, and shared immersive visualization. In a virtual world, you have a tangible “sense of presence” that you are really there. What's more, if you are working with collaborators, you are all looking at exactly the same three-dimensional scene, each from your own point of view, and you can see where the others are. This allows for a richer and more natural collaboration than can be achieved over the phone with each collaborator looking at his own desktop.

The Meta Institute of Computational Astronomy (MICA) is an organization of astronomers dedicated to realizing the potential of virtual worlds for scientific research. We have weekly professional seminars, public outreach events, and workshops. Please join us! See our website for more information, and our poster 477.05 on Thursday.

http://www.mica-vw.org