Solar System Simulator

Use Newton's Law of Gravity and his laws of motion to simulate interactions between planets.

User-defined solar system; can be like our own, or totally different

User can control simulation rate

Animations can be created and exported

GTK+ toolkit allows program to run on Linux, Windows, many other platforms

Laws of gravity

There are several!

Copernicus, Brahe & Kepler
Newton
General Relativity
Quantum Gravity
String/M-theory

Simulator will start with Newtonian model of gravity

Newtonian gravity

Force is exerted between all bodies in the universe:

$$F = -\frac{Gm_1m_2}{r^2}$$

Masses:
    Sun: 2e30 kg
    Jupiter: 2e27 kg; Saturn: 6e26 kg
    Earth: 6e24 kg

Smaller planets do not affect each other much

Force that attracts the Earth and Sun = 3.6e22 N
Force that attracts Earth and Jupiter ~ 1.4e18 N

Calculating displacement

Each frame, take time since last frame drawn

Calculate force on object and hence acceleration

$$f = ma$$

$$s = ut + 1/2at^2$$

Use kinematic equation to calculate displacement

Simulation loses accuracy if frame-rate is low

Decouple display process from simulation logic
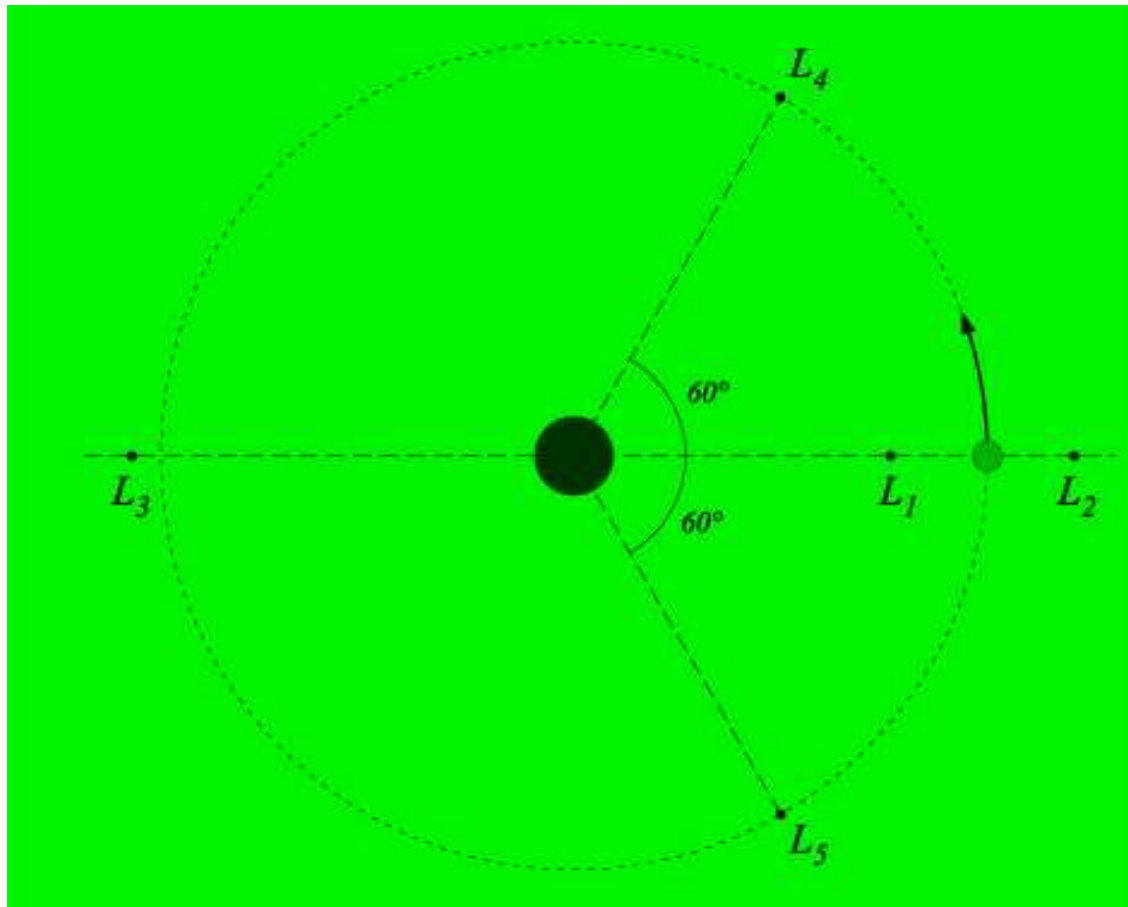
Interesting stuff

Asteroid belt
Rogue planet (heavy) disrupts peaceful solar system
Slingshot maneuver

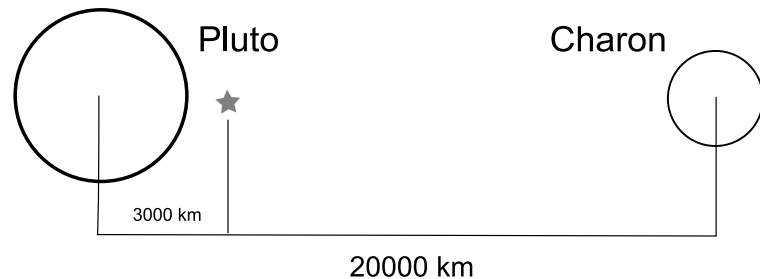Lagrange points

Interesting stuff

Centre of mass

Pluto: 1.2e22 kg
Charon: 1.8e21 kg
Factor 7 difference

Distance between the two: 20,000 km
Therefore centre of mass is 3,000 km from Pluto's core

Pluto's radius is only 1,200 km

Pluto   Charon

3000 km

20000 km

Binary systems

General Relativity

Newton: gravity is everywhere, all the time

Einstein: gravity propagates at a measurable speed

What if the Sun ceased to exist?
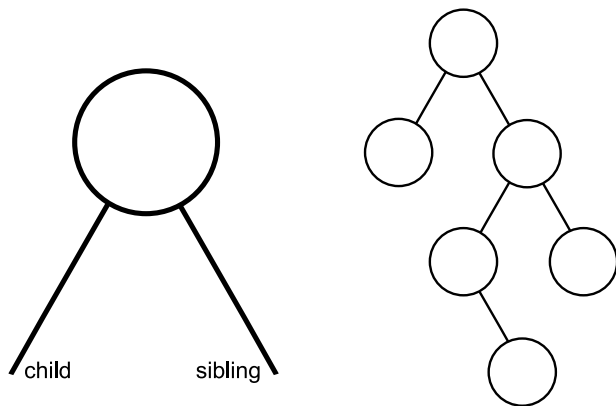
Simulating GR

Drawing the scene

Size of planets must be distorted

Stars, planets, moons related as children and siblings

This gives us a nice binary tree representation
Can draw this recursively:
Push matrix, offset from parent, draw self, draw child, pop matrix, draw sibling

child   sibling

three planets
first has one moon, second has two

Making it pretty

Texture mapping
    Planets
    Celestial sphere

Info boxes
    Planetary data

    Depiction of forces acting on planet, resultant force

Gravitational contours
    Field lines become closer together where field is stronger