~~Gr~~ Gravity
~~St~~ Simulation Date:

$1\,d = 86{,}400\ s$

- Δt

Real time is continues, but computers can only ~~fix~~ step in finite chunks

Positions and velocity are updated by:

$$v(t+\Delta t) = v(t) + a \cdot \Delta t$$

$$x(t+\Delta t) \approx x(t) + v \cdot \Delta t$$

Date:

- Vector position of object

a 3D vector $= \cancel{x}\ r = (x, y, z)$

describes where the object in space

- Velocit vector for objects in space

$$\boxed{v = \frac{dr}{dt}}$$ → To find velocity of objets in space

rate of change of position, both direction and speed.

- Acceleration Vector for objects in space

$$a = \frac{dv}{dt} = \frac{d^2 r}{dt^2}$$ ← To find acceleration

Date:

Important

- MASS → Source of gravity

Newton's law:

$$\boxed{F_{ij} = G \frac{m_i m_j}{r_{ij}^2}}$$

[we will use both gravitational pull and visual depth of space and time]

Date:

- gravitational force and acceleration

$G = 6.67430 \times 10^{-11} \, m^3 kg^{-1} s^{-2}$

[rescaling of G for proper simulation]

- Sepration of for two bodies

$r_{ij} = r_j - r_i$

[where ij will be co-ordinates of bodies]

- distance between bodies and Scaler vector position

$$r = \sqrt{(x_j - x_i)^2 + (y_j - y_i)^2 + (z_j - z_i)^2}$$

Date:

- Newton Law of Gravitation —
→ accleleration

$$a_j = G \sum_{j \neq i} \frac{m_j \, r_{ij}}{|r_{ij}|^3}$$

- Note
  - each body accelrates towards all others.
  - The denominator r^3 arises because force $\propto 1/r^2$ and accelration is force/mass

$$\text{force} \propto \frac{1}{r^2}$$

$$\text{accelration} = \frac{\text{force}}{\text{mass}}$$

for Simulation

Date:

- orbit Intialization (Circular Speed)

Velocity of Circular orbit, of radius r around Mass M

$$v = \sqrt{\frac{GM}{r}}$$

- Centripetal force = gravitational force

$$\boxed{\frac{mv^2}{r} = \frac{GMm}{r^2} \Rightarrow v = \sqrt{\frac{GM}{r}}}$$

- Numerical Physics for updation of Velocity and position of bodies.

Date:

$$\boxed{\begin{aligned} v(t+\Delta t) &= v(t) + a(t)\,\Delta t \\ r(t+\Delta t) &= r(t) + v(t+\Delta t)\,\Delta t \end{aligned}}$$

motion of bodies in simulation is approximated continuously step by step.

7. Fabric of space time

~~$y(x, z) = \sum_{bodies} (-0.1 \cdot m)\, e^{-(x - x_{ij})^2 +}$~~

$$y(x,z) = \sum_{bodies} (-0.1 \cdot m)\, e^{-\frac{(x - x_{ij})^2 + (z - z_{ij})^2}{10m}}$$

Date:

gaussian function is used ~~to~~ on each body.

mimics "gravitational well"

but it is not real general ~~relati~~ relativity

- Not real general relativity.

Using gaussian for "gravitational well" to look smooth

Date:

~~File layout~~

[My approch]

1) [Using actuall physics and general relativity for simulation of Solar System not just random Values]

2) Making it optimize for real time computational

3) each planet with it's info for astronimical lover's.

4) Most important [approximating physical

Date:

quanties for my computer to calculate] :)

5) future updates like
- ·) brief info or video of each Planet
- ·) more ~~galxies~~ galaxy and celestial bodies.
- ·) A python based space simulation system with actual physics.

Date:

1) Units and Constants
(keeping no.s sane)

distance = AU
time = Year
mass = solar masses.

$G = 4\pi^2 \, (AU^3 \cdot M_\odot^{-1} \cdot yr^{-2})$

Speed of light $c \approx 63241$ AU/yr

Date:

2) Body state & derived quantities.
each planet and sun has

m, radius R (approximate note realistic but actual no. shorten down)

$V = \frac{4}{3}\pi R^3$ - Volume

$\rho = m/v$ - density

Orbital period $T = 2\pi\sqrt{\frac{a^3}{G(M_\odot + m)}}$

angular momentum $h = r \times v$, $|h| = \sqrt{G(M_\odot + m)\, a(1-e^2)}$

Important

Date:

3) Newton's N-body core

$$\boxed{a_i^{(N)} = G \sum_{j \neq i} m_j \frac{r_{ij}}{|r_{ij}|^3}}$$

where, $r_{ij} = r_j - r_i$

N massive bodies (Sun + 8 planets) at each step.

Update rule ($\Delta t = dt$);

$$\boxed{v_i^{n+1/2} = v_i^n + \frac{1}{2} a_i^n dt}$$

$$\boxed{r_i^{n+1} = r_i^n + v_i^{n+1/2} dt}$$

Recomputing Values

$$V_i^{n+1} = V_i^{n+1/2} + \frac{1}{2} a_i^{n+1} dt$$

My approch importat part

Date:

4) Relativity without a Super computer : 1-Post-Newtonian (1PN)

$$\boxed{a_{PN} = \frac{GM}{c^2 r^3}\left[\left(4\frac{GM}{r} - v^2\right) r + 4(r \cdot v) v\right]}$$

$$\boxed{\Delta\omega \approx \frac{6\pi GM}{a(1-e^2)c^2}}$$

Date:

5) Gravitational well
(actuall one with shorten down values of bodies)

- Newton's potential surface

$$\Phi(x,z) = G \sum_k \frac{m_k}{\sqrt{(x-x_k)^2 + (z-z_k)^2 + \epsilon^2}}$$

Render height

$$y(x,z) = \alpha \Phi(x,z)$$

- Schwarzchild embedding for sun (GR looks near the sun)

$$y(r) = \pm 2\sqrt{r_s (r - r_s)}$$

Date:

File layout of project
(By my logic)

Solara_Sims/
constant.py → all the contants
physics/
element.py
nbody.py
gr.py
osculating.py
diagnostics.py
⋮
data/
solar_data.json
model/
body and system

Planets/
planets with their physical quantities
in.py.