Fluid Simulation with Smoothed Particle Hydrodynamics(SPH) method accelerated with Compute Shaders

Final project for the practical course in Computergrafik 2016

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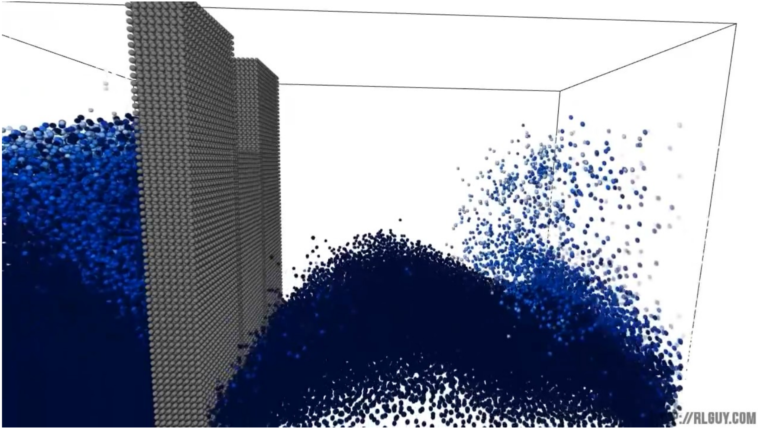
Fluids

- Liquids, e.g. water
- Gasses, e.g. air
- Plasmas

Introduction/Motivation



source: https://youtu.be/iHACAlfYeiQ

Navier-Stokes-Equations

Equations which describe the motion of viscous fluids.

We use the Navier-Stokes-Equations for incompressible fluids with constant density:

$$\frac{\partial \boldsymbol{v}}{\partial t} + (\boldsymbol{v} \cdot \nabla)\boldsymbol{v} = \boldsymbol{g} - \nabla \frac{\boldsymbol{p}}{\rho} + \frac{\mu}{\rho} \nabla^2 \boldsymbol{v}$$

where $\boldsymbol{v}$ is the velocity, $\boldsymbol{g}$ is the gravity, $\boldsymbol{p}$ is the pressure and ρ and μ are the material properties density and dynamic viscosity.

Smoothed Particle Hydrodynamics

Physical property Φ_i at position r_i is computed in a sphere with radius h:

$$\Phi_i = \sum_j m_j W(h, \boldsymbol{r_i} - \boldsymbol{r_j})$$

W is the weighting function which sums to 1 over radius h and drops to 0 outside of h.

Smoothed Particle Hydrodynamics

$$\rho_i \approx \sum_j m_j \frac{315}{64\pi h^9}\left(h^2 - \|\boldsymbol{r_i} - \boldsymbol{r_j}\|^2\right)^3$$

$$p_i = \rho_i - \rho_0$$

$$\frac{dv_i}{dt} = \boldsymbol{g} - \frac{\nabla \boldsymbol{p_i}}{\rho_i} + \frac{\mu}{\rho_i}\nabla^2 \boldsymbol{v_i}$$

$$\frac{\nabla \boldsymbol{p_i}}{\rho_i} \approx \sum_j m_j \left(\frac{\boldsymbol{p_i}}{\rho_i^2} + \frac{\boldsymbol{p_j}}{\rho_j^2}\right) \frac{-45}{\pi h^6}\left(h - \|\boldsymbol{r_i} - \boldsymbol{r_j}\|\right) \frac{\boldsymbol{r_i} - \boldsymbol{r_j}}{\|\boldsymbol{r_i} - \boldsymbol{r_j}\|}$$

$$\frac{\mu}{\rho_i}\nabla^2 \boldsymbol{v_i} \approx \frac{\mu}{\rho_i} \sum_j m_j \left(\frac{\boldsymbol{v_j} - \boldsymbol{v_i}}{\rho_j}\right) \frac{45}{\pi h^6}\left(h - \|\boldsymbol{r_i} - \boldsymbol{r_j}\|\right)$$

$$\frac{dv_i}{dt} = \boldsymbol{g} - \frac{\nabla \boldsymbol{p_i}}{\rho_i} + \frac{\mu}{\rho_i}\nabla^2 \boldsymbol{v_i}$$

Evaluation

Content:

- very few Parameters
- no assumptions about the data, but still meaningfull results
- comparable performance to established methods
- Parameter choices still existent:
    - motif_length
    - background_noise
    - conversion from audio data to spectogram
    - MPEG encoding

Evaluation

Presentation:

- good Visualization with spectograms and graphs
- Pseudo Code is a bit confusing
- Code not directly accessible, unlike stated in the paper
- Enclosed code is in a bad state, bad documented

Thank you for your attention

Any Questions?
Feedback?

Sources