GPU Particle Simulation for Games

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Introduction

• For years games use graphical particles to add visual effects
• For years games use physical simulation to create immersive interactive worlds
• Technologies like CUDA or DirectCompute allow general GPU computation
• Combine these to create GPU particle simulation engines
GPU Particle Collision

• Simulate massive amounts of particles interacting with the game environment
  – Debris from weapon impacts
  – Sparks
• Non-interacting spheres
• Use Collision Normal to Orient Non-spherical Shapes
GPU Particle Simulation
**Fluid Simulation - SPH**

- SPH = Smoothed Particle Hydrodynamics
- Simulate fluids such as liquids or gases
- Rendering
  - Explicit surface rendering for fluids
  - Sprite-based methods for smoke or fog
- Examples:
  - Viscous liquids such as blood or goo
  - Gases like smoke
Position-based Fluids

- Stable for large timesteps, making it more
- Suitable for real-time simulation
- Supports surface tension
- Supports collision
- Similar uses to SPH

gameworks.nvidia.com
Position-based Fluids Example
Turbulence

• Grid-based fluid simulation
  – Start by simulating turbulent flow of a fluid
  – Add GPU particle simulation with collision
  – Use the fluid simulation to apply forces to particles
  – Result is particles that move in interesting ways, and react with the environment
Turbulence Smoke Effects

- Turbulence simulation can enhance smoke effects
- Start by simulating turbulent fluid
- Add GPU simulated particles moving in the fluid
- Render as self-shadowed particles
- Move objects through the fluid to create a convincing smoke effect
- Enhance with PSM - Particle Shadow Mapping
PSM Example
Turbulence Examples

- Moving the fluid creates interesting motion on its own
Turbulence Example

- Moving objects through the fluid stirs up vortices
Turbulence Example

- Add built-in noise to have vortices from the beginning of simulation
Turbulence Example

- Heat sources stir the fluid as well
Turbulence

• You can Layer other force fields
  – Jets pushing through the fluid
  – Attractive or repulsive forces
  – Radial force fields
  – Noise fields
Turbulence in Games

- Hawken, PlanetSide 2 ...
Turbulence Authoring

• We want to give the artist tools to:
  – See rendering of particles as it will be seen in the game
  – Layer multiple particle simulation objects to create the final effect
  – Package all of these together to make an effect that can replicated throughout the game
  – See the results of changes in real time
Turbulence Authoring

• Layer multiple particle simulation objects to create the final effect
  – Particle simulation with collision
  – Emitter to create the particles in the appropriate way
  – Turbulence fluid simulation
  – Other fields such as heat sources or noise fields
  – Particle rendering options
Q&A