Attribute-Aware Radial Basis Functions:

Interactive Visualization of Time Series Particle Volumes using RT Core Range Queries

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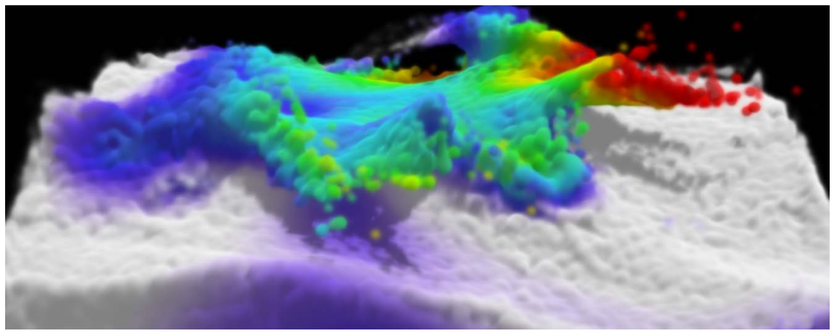
Abstract

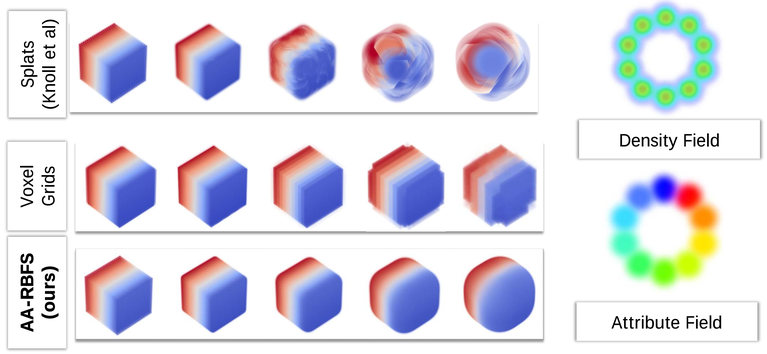


Smoothed particle hydrodynamics is commonly used to simulate fluids, astrophysics, and solid mechanics. Our new method enables interactive rendering of these time series particle volumes by repurposing ray tracing cores on modern GPU architectures.

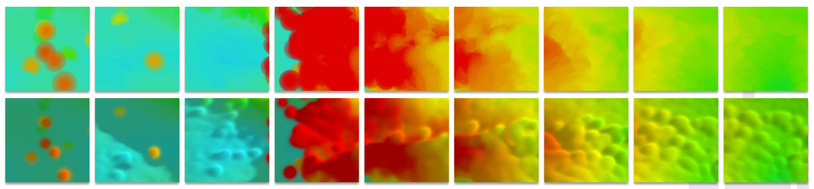
Our method allows users to visualize both relative particle density as well as per-particle attributes (temperature, mass, velocity…), enabling scientists to see how particles are distributed, and what particles represent.

Finally, we enhance interactive rendering quality through a novel volumetric shadowing method (see the image above), enabling better depth perception.

Related Work

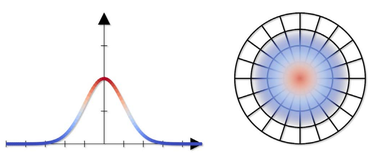


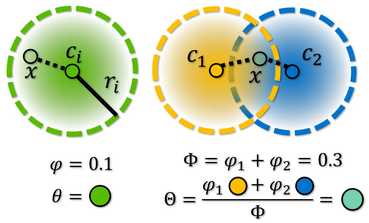
Previous techniques cause visual artifacts when particles overlap. Our attribute-aware radial basis functions robustly handles these cases. Other methods only render density fields. We extend to support attribute fields.



Previous splatting methods (top row) fail to convey depth information. Using our AA-RBFs (bottom row), we can interactively render volumetric shadows, better conveying depth information in the data.

Extending RBFs to support color-attributed data



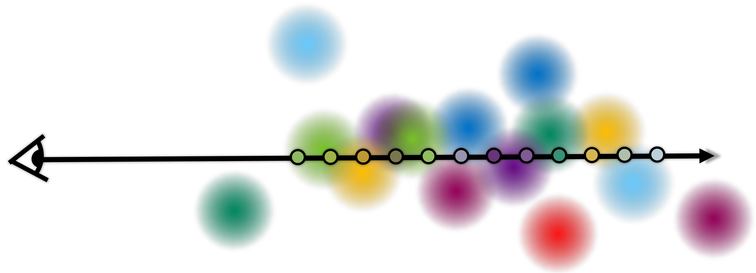


Use radial basis functions “φ” to drive a weighted interpolation of per-particle attributes “θ”, enabling scientists to visualize these attributes through color.

Field Reconstruction using RT Core Range Queries

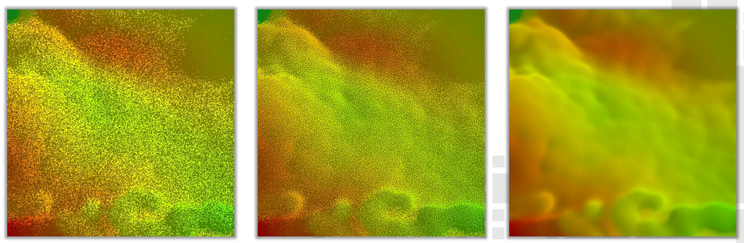
Use ray tracing hardware to return all particles within 3σ of a query point. This allows us to query millions of particles in parallel on the GPU, enabling interactive volumetric ray marching and distance sampling methods.

Volumetric sampling using world-space queries



Direct world space queries allow us to adopt rendering methods used in other common volumetric formats, while also allowing particles to move over time.

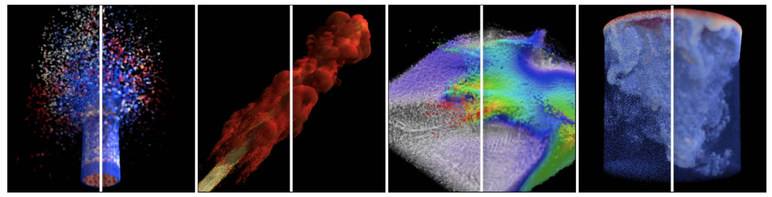
Volumetric shadows to improve data perception



White Noise (1SPP, 23FPS) | STBN (1SPP, 46 FPS) | Ground Truth (4K SPP, 3 minutes)

Spatio-temporal Blue Noise (STBN) can be used to drive distance sampling, enabling users to distinguish between features and noise over time.

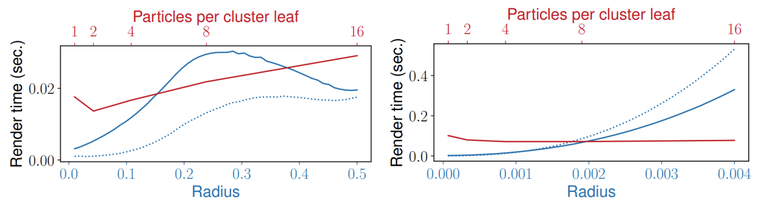
Datasets used for evaluation



(a) Nozzle	(b) Uintah Boiler	(c) Dam Break	(d) Viscus Fingers
100 M Points	253 M Points	105 M Points	67 M Points
768K Points / Step	23,079 K Points / Step	768 K Points / Step	550 K Points / Step
105 FPS (9.5 ms)	6.79 FPS (147.2ms)	46 FPS (21.7 ms)	24 FPS (41.7 ms)

Interactive to real time rendering performance for all datasets evaluated.

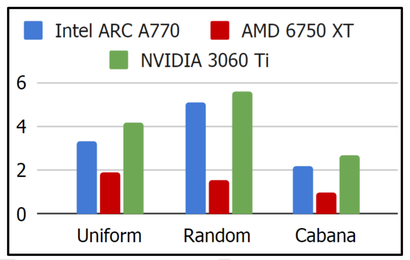
Performance characteristics of particle radii



(a) Viscus Fingers (b) Uintah Boiler

Our findings show that large radii can slow down rendering performance, but that clustering large particles together can help.

Improvements from Ray Tracing Cores



Relative improvements over software tree traversal **(Higher is better)**

See animations here:

Code is here:

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