Volume Modeling Techniques in The Good Dinosaur

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Figure 1: *Left: The storm cloud, constructed from roughly 1000 curve primitives and layered fluid simulations. Right: The whitewater on top of the river surface and the waterfall foam were constructed from procedurally instanced line primitives.*

Abstract

In a recent paper, we introduced the *Reves* volume modeling algorithm [Wrenninge 2016]. Pixar's latest animation film, *The Good Dinosaur*, was the first production to use the system, and this submission aims to show the tool in practical use. Although Reves is designed to produce *temporal volumes*, it is a flexible and powerful volume modeling tool for static volumes as well.

Two key aspects of Reves are its use of an intermediate rasterization representation (microvoxels), and is its scalability. The microvoxel representation means that a wide variety of input primitives can be handled, with efficient SIMD execution of shaders. The scalability provides consistent behavior to the user: at low resolutions feedback is fast and small primitives antialias consistently, and at high resolutions memory use is well controlled. This, together with robust shader and coverage antialising, means that the system can be relied on to produce consistent results at any given output resolution. For the user, it means fast interactive feedback that closely matches final quality.

Keywords: cloud modeling, cloud rendering, multiple scattering

Concepts: •**Computing methodologies** → **Ray tracing; Volumetric models;**

1 Working with Reves

Our implementation of Reves is Houdini-based, with rasterization taking place in the SOP (Surface Operation) context. We aimed to make all geometric primitive types rasterizable, and to that end our custom SOP recognizes particle systems, curves, surfaces, as well as volumes. Each primitive acts as a proper volumetric solid (as opposed to previous systems that could only fill more complex primitives with points) and can be assigned a unique CVEX (context-free VEX) shader, which makes it straightforward for users to procedurally add detail, and to customize the combination of noise types to a particular effect. A custom lattice primitive makes it possible to deform existing volumes with intuitive control, and all primitive types may be mixed and matched arbitrarily.

Storm Clouds On *The Good Dinosaur*, the two main uses for Reves were to construct whitewater and foam for the multiple rivers that appear in the film, as well as for art-directed storm cloud formations.

The storm clouds were constructed from around one thousand curve primitives with an applied pyroclastic shader. The CVEX shader system made shader development simple, and the final look used layers of 4D noise to give the impression of both advection and evolution in the cloud. In selected areas, the procedural volume was augmented with a clustered set of Houdini Pyro simulations, adding further dynamics.

The setup leveraged several of Reves' features: shading rate could be set per curve, such that primitives buried inside the volume rasterized with lower detail while still providing the desired bulk, and region-of-interest controls were used extensively to get quick feedback at final-quality resolution.

Whitewater The river in *The Good Dinosaur* was built using multiple layers of FLIP simulations, and the foam and whitewater effects were created from the surface and spray particles. Because the particles were sparse, a procedural Reves plugin was used to generate curve primitives at rasterization time from the input particle system. This technique is similar to the *clustering* technique described by Wrenninge [2011], but produces true line segments instead of instanced particles. Because Reves uses bucket-based rasterization, the procedural only kept a bucket's worth of line segments in memory at any given time, making for efficient memory use.

References

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