Simulating Rivers in The Good Dinosaur

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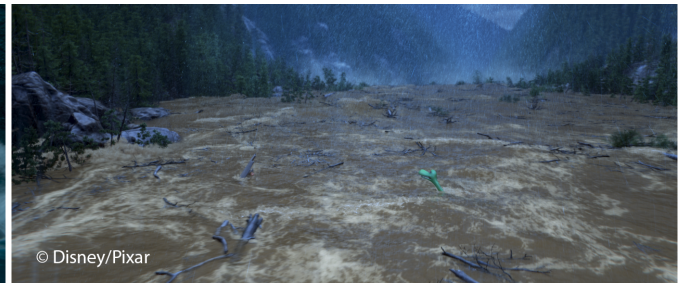

Abstract

Pixar's *The Good Dinosaur* is a journey through nature, with the environment and all its perils playing a major role alongside Arlo and Spot. The river they travel along is both an obstacle and a guide, and serves as a key storytelling tool – the film's yellow brick road.

Because the rivers were so prominent, a linear department workflow was impractical; for the layout department to design shots they needed a reliable representation of the river, such that the features they designed the shot towards would stay consistent throughout the rest of the pipeline. In order to achieve this, a sequence-based workflow was adopted, where the river acted the same as any asset in the set. In the end, sections of river as long as a half mile were simulated in order to give the film makers the necessary flexibility.

Keywords: water, simulation, rendering, multiple scattering

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

1 Approach

Each river section was composed of the same set of elements. The base water surface was a subdivision mesh and the splash particles simple RiPoints. Volumes were used to represent foam on top of the surface as well as splashes and whitewater above the surface. The base mesh used cycling UV coordinate systems to track noise-based displacement and also a custom raymarcher to handle below-surface volumetric light scattering.

The assets were structured with a hierarchical layering approach in mind: Each river asset used a single base mesh, but all of the particle and volume data sets were divided into separate regions (clusters), such that on a per-shot, per-cluster or per-frame basis, any of the individual clusters could be swapped out for a more refined version.

Simulation In order to simulate long sections of river, a process of gradual refinement was used. First, a base FLIP simulation was run with the goal of establishing the general feel of each river section. Once approved, the coarse simulation was used as the initial state to a higher resolution simulation. After the simulation step, a highly parallelized approach took over. Surfacing, foam and whitewater generation all employed a clustered approach where different regions of the simulation were simulated separately. This approach not only enabled parallel execution, but also provided structural granularity, such that clusters could be replaced during shot work.

With all the data in place, the layout department could work with a low-resolution polygonal representation to design shots, and trust that the final rendered images would render consistently.

Particles and Volumes To achieve the feel of a raging river, we found it necessary to use a combination of both particles and volumes in addition to the base surface. Particles conveyed the appearance of individual water droplets, where specular shading response is important. For whitewater, foam and froth, volumes were used.

The volumetric elements used a voxel size of 1cm, resulting in an effective resolution over $80000 \times 10000 \times 3000$ for the largest river section. Each cluster was saved to disk as a Field3D MIP volume, enabling the renderer to choose the appropriate resolution based on camera position. To provide sharp detail, some shots required clusters close to the camera to be rasterized at $\frac{1}{2}$ to $\frac{1}{4}$cm voxel size. In total, each of the seven river sections used 10-30TB of space.

Rendering Light scattering is an important visual aspect of aerated water, and in order to give depth to our volumes, we employed the same multiple scattering path tracer plugin as was used for rendering clouds in the film. The accompanying video shows examples of the whitewater rendered with and without multiple scattering.

2 Conclusions

Initially, the idea of simulating entire river sections seemed daunting. Effects artists traditionally ran one simulation per shot which ensured full control over the motion of water. However, our workflow of breaking large sections into individual clusters allowed us to overcome the limitations that would normally come with using a single asset for multiple shots. In the end, we were able to offer the layout department full freedom in designing shots, with confidence that high resolution data was available throughout the set, and with the option of replacing parts of the asset per-shot in cases where the camera was very close to the water surface.

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