End of the World Waterfall Setup for "Pirates of the Caribbean 3"

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1 Mission / challenges

For Pirates of the Caribbean 3, we were challenged to create larger than real life waterfall. Our mission was not only to create the tools to render the realistic look but also the pipeline for achieving maximum flexibility, speed and artistic control for shot development.

Primary challenges we tackled to achieve the effect include node based daisy-chainable column setup, creation of the "library trail" tool for achieving realism, volume compositing and previewing for landscaping of the waterfall, shader compositing for seamless transition from underwater to waterfall, "3D element concept art" to take advantage of compositors/art directors skills to boost the iteration cycles for generation of 3D elements.

2 Building waterfall columns

Waterfall is built as a collection of waterfall pieces called "columns". First goal of the development was to create a flexible system that allowed us to quickly generate wide variations of realistic columns. Columns were made out of 1 to 10 column sections called "micro-columns". Artist would first build a library of daisy-chainable nodes, with exposed parameters that generate the micro-columns. These micro-column generators did not care about how the micro-column was generated inside, only the ability to receive a chain of micro-columns as an input and be able to pass on the result to the next. This daisy-chaining approach gave artists three great advantages, the ability to focus on building a specific feature of a column, without needing to know how other artists built their micro-column, the ability to share the generators that other artists have built, and maximum flexibility to build the final column by mixing, matching and daisy-chaining them together. Once a column is built, it’s saved to disk as a 3D voxel file and becomes the building block of the final waterfall. (See Figure 1)

3 Working with the columns

Once these fundamental columns were prepared, they were used in several ways to build the final waterfall. Effects concept art at Digital Domain is usually created by painting and/or piecing together real footage, which is then gets handed over to 3D artist to recreate the look in 3D. Typically it takes a great amount of artistic work to recreate the concept in 3D. For the waterfall, we decided to create concept art using primarily the rendered columns. This method of creating the concept art utilizes compositors/art directors specialized 2D skills to define the look of the 3D elements. Recreating the concept in 3D is straightforward, since it’s using the rendered columns. For shots where the camera angle/movement was not suitable for column based concept art, landscaping of the waterfall was done by blocking the block placement in 3D, by scaling / transforming the iso-surface representation of each columns. This allowed artists to block the final waterfall at an interactive speed. Having library of 3D columns stored as voxel format on disk excels at render time, for having the ability to transform and merge as many columns as you wish to make the final waterfall. Rendering is also efficient since no additional voxel data needed to be regenerated, and RAM use is minimal by streaming them from the disk.

4 Detail look development

Rendering a realistic detail of the waterfall beyond any work seen was a challenge on its own. Waterfall typically consists of very fine detailed water droplets, and the cloudy trail which the droplets turn into over time. The typical point rendering method excels in capturing the detail and the motion of the fine droplets, but not best suited for representing the smooth volume, such as trails. Instancing more points at render time with low density would achieve trailing but this is not best utilizing the strength of the point rendering over voxel rendering. Voxel based volume rendering excels in representing a smooth volume, but not best suited for controlling the detail and the animation of the fine droplets. Hybrid approach was developed which combines the best of both approaches. The tool is voxel based which bakes anti-aliased user defined key framed point clouds (called "library", i.e. particle sim, or single frame key shape) into the voxels, it then switches to volume filling mode and draws volumetric trails off of each library point position. This approach gives the ability to smoothly transition from detailed point rendering to volumetric trailing effect, accurately off of the render-time point clouds. (See supplemental movie)

5 Putting it all together

Once these concepts/blocking are created, final waterfall was rendered in one of the four methods, depending on the requirements of the shot. (A) Some wide angle shots were achieved by projecting the concept art back onto the waterfall grid in 2D. (B) Rendering a hybrid elements, which consist of fully 3D renders for areas that required more perspective, and blending into the projected column concept art in areas where perspective was less notice able. (C) is where all columns were re-created to match exactly what the concept art did. This was simply a matter of applying the 2D transformations that compositor / art director applied to create the concept, back into 3D column transformations. (D) Fully 3D rendering of the waterfall, using the iso-surface blocking.

3D elements were rendered in two passes, foreground layer for volume above the waterfall holdout, and background layer which contains the result of the ray march, starting from the holdout on. Along with it’s z-depth, and the normal and view vector renders from the water surface, underwater shader work such as depth fading and refraction was done in compositing, to create the seamless transition of the volume from underwater to into the air.

References

PETERSON, S. 2003. Building a waterfall 1,000 particles at a time for “Shrek 4d”. ACM Trans. Graph. 2007 © Digital Domain, Inc. All rights reserved.