Deconstructing Destruction

Making and breaking of "Frozen 2"'s Dam

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Figure 1: The Dam before and during its destruction

ABSTRACT

In "Frozen 2", a key story point is centered around the destruction of a large dam. The scale and scope of this effect necessitated the development of a cross-departmental, effects-driven workflow. Effects were introduced and planned at the layout stage before animation to choreograph the dam collapse sequence and to enable the animators to have the character react to the destruction. During this show, we also further developed the ILM workflow integration at Walt Disney Animation Studios (WDAS) [?].

CCS CONCEPTS

Computing methodologies → Physical simulation;

KEYWORDS

vector displacement, modeling, destruction, houdini, bullet, collaboration

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1 INTRODUCTION

Early in the production of "Frozen 2", we knew that the dam would be an integral part of the storytelling of the movie, and that the destruction of the dam would be at the climax of the movie. As such, the dam appeared in a number of shots and needed to be optimized for both close-up and far-away shots. The way the dam shattered not only drove layout and camera placement, but also

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animation performance so that we could animate proper reaction to the destruction and feet contact with falling debris.

This required a new cross-departmental workflow different from the traditional workflow at Disney Animation in the sense that this sequence was organized to be effects-driven and required almost every department to set the effect up correctly. This was a highly collaborative effort that involved a large number of departments taking place in an unusual order . The following sections present the steps we went through to be able to achieve this sequence.

2 APPROACH

2.1 Effects/Layout

Since a character is interacting with the dam while it is breaking apart, the timing of the destruction had to be carefully planned out with layout to help determine the camera angles and choreography. This was done on a scout version of the dam. The effects department previz planning greatly helped determine which area of the dam should be tweaked in terms of modeling/look and where to place the camera. It was also a great way for the Effects department to get involved early on in the design decision of the dam.

2.2 Modeling

Since we knew that the dam would be progressively destroyed throughout the movie, we decided that the final model would be constructed out of individual, fully-realized blocks instead of a single surface with a block texture. However, this model would have been too heavy to quickly iterate in the early phases of production, so we started by building an initial, low-resolution "scout" version of the dam. This allowed our Art Director, Director of Cinematography, and Head of Effects to design the proportions, composition, and action for the sequence with support for quick changes by the modeler. Once we had determined the design and general proportions of the dam, we began building the final, high-resolution model. This model contained 17,841 individual blocks to allow for a more realistic destruction simulation.

To create a handmade appearance, special care was taken to vary the size, shape, and placement of the individual stones while avoiding any repeating patterns. This was particularly difficult due

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to the need to lay out these irregular interlocking patterns across a curved surface of the dam. One of the biggest challenges was creating enough variation while avoiding overlap between adjacent stones. This was necessary so that the stones would not be pulling out of each other as the dam breaks apart. Aesthetically, it was important that details on the dam helped support the story behind its construction: since the stone would have been cut by hand from the surrounding fjord walls, we sculpted in high-resolution detail and imperfections into all of the surfaces.

The cliffs around the dam held an entirely different challenge. Much of the cliff face is only seen from a distance while other parts are seen very close up and even contacted directly by characters making a huge range of detail needed for different parts of the model while needing to appear consistent. The entire cliff was sculpted to a high level of detail in ZBrush. Different areas of the cliff were broken apart according to how those areas were used in shots and then low resolution meshes were created at different levels appropriate for the usage. Then the high resolution sculpted detail was captured as vector displacement maps which were applied back onto the different mesh levels during the look process. This allowed for much lighter geometry where it was not necessary for character interaction while maintaining consistent detail across different areas in the final displaced rendered geometry.

2.3 Look

For the look, we started from the materials and color palette of the original fjords and applied them to the blocks making up the dam. Using our proprietary texturing software, Paint3D, and our open source expression language, SeExpr [?], subtle material variation and uniquely rotated cut-mark textures were applied to each individual block. This added a visual richness by reinforcing the idea that the individual blocks were hand cut from the fjords and then assembled.

For the 30-year-older version of the dam, we used Disney's XGen and our new proprietary interactive vegetation placement tool, Droplet, to paint down hundreds of thousands of instances of moss, grass, mulch, and other vegetation to add a geometrically complex yet art-directable realism to the surfaces in the model. However, as these surfaces were also going to fracture apart during the climax, we also had to enhance these systems to maintain their position and attachment to the surfaces as their topology changed within a shot.

The work was challenging from a Look Development viewpoint due to the amount of destruction on many different shots of various distances and angles. Making the dam look good is one thing, but making sure it is aesthetically appealing during destruction is



(a) Disney's XGen moss (b) Interior details Figure 2: Details on the dam.

another. The inside face integration with the modeled block look is just an example. We also had to take into account our thousands of instanced moss and grass procedurals that are scattered on the dam adhering to density control maps. Lastly, all of the dams materials, textures, and procedurals had to be editable at any part in the process in case we get any production designer notes along the way.

2.4 Effects RBD/Animation/Effects finaling

The effects department worked hand in hand with the modeling department to make sure all the meshes met the requirements to properly simulate the dam's destruction. We used Houdini engine wrappers around OTLs in Maya to make sure we were checking the geometry in a consistent manner. The dam was pre-fractured only once and this data was shared between the different shots. This helped greatly with efficiency and consistency across the sequence since all the destructed pieces had to work with our internal renderer Hyperion [?] and have Ptex textures [?]. Extra geometry and higher detail in the fracturing were added to one area where we see the broken dam closer and from a more static camera in order to showcase the interior stone structure.

The destruction shots were driven by FX. The detailed modeling and simulation were completed before the final animation so that Anna's feet could match the moving and crumbling surface of the dam and she could react to the destruction around her. Once the rigid body simulation (RBD) was director-approved, it would go to layout for camera readjustment, then character animation and character effects before circling back to effects where we would add secondary dust, debris and particulates, alongside running the water simulation. In most cases, the water simulation was run after the destruction with the water reacting to the RBD rather than the other way around. The continuity of the action also allowed us to optimize the simulations by running a longer simulation which would span over several shots. Careful timing, choreography and planning throughout the previz phase by our Heads of Effects also facilitated simulation reuse over several shots.

3 CONCLUSIONS AND FUTURE WORK

"Frozen 2" presented a challenge to be able to optimally destroy a dam in a continuous fashion. Departments worked together, overlapping in a way that they are not used to. The final results are rewarding and this workflow added a lot of interest and realism to the sequence.

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