Elemental Characters: The Living Vegetation of Element City

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ABSTRACT

The Earth characters of Pixar's *Elemental* feature a wide range of foliage adornments, ranging from bushes and small plants to trees that tower over their bodies. Creating appealing motion for each of the variations of these characters presented a unique challenge to the Simulation Team, and led to a significant expansion of the existing simulation pipeline. These characters needed to believably co-exist in a world with set-dressed foliage, while also interacting with the diverse and mechanically challenging environment of Element City. In order to meet the demands of a film featuring crowded mass transit, high levels of action, and trees that prune each other, a new series of tools were created to allow Pixar's Simulation artists to apply the most powerful tools at our disposal to the most appropriate tasks.

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1 HISTORICAL APPROACH

Historically, Pixar's vegetation has relied largely on traditional animation tools. Given that most foliage elements are typically too dense for efficient simulation, vegetation simulation has been implemented only when required in specific shots. Where previous films such as Pixar's *Finding Dory* have made animating vegetation a process by our Sets team [Fariss and Carysforth 2016], our other films like *Luca* and *Turning Red* have turned to Simulation to resolve recurring character interaction with set pieces such as trees and grass. *Elemental* not only necessitated more foliage interaction than previous films, it introduced a large set of characters made up of foliage that could no longer be treated as stationary setpieces. To adequately simulate the unique motions and interactions of our Earth characters throughout the film, it became clear that we needed a more scalable approach with better simulation controls. While planning out the requirements for this new approach, it also became clear that the Simulation team would need to take an earlier and more active role in creating the character's look and asset structure.

2 CLOTH-BASED FOLIAGE

The first true test of our simulation vegetation pipeline arrived in the form of Fern, a stationary character who sits completely encased in vines and fronds. Because his model was too dense to process by hand, we leveraged procedural tools to de-intersect and recreate Fern's foliage as optimized simulation meshes. While the majority of Fern's leaves were simulated as cloth, tetrahedral meshes [Campbell and Jarvers 2020] were used to represent vines in his hair and mustache. Our internal solver, Fizt2, was very successful at resolving larger leaves that needed highly accurate collisions. To further control the motion of his surrounding leaves as he moved

about, we re-dressed much of the foliage on a per-shot basis, using additional rigging for finer control before and after simulation.

It took several iteration loops to nail down the precise look and behavior of the foliage, and this process was applied to many of the smaller characters with simple plants or leaves. It was apparent, however, that this approach would not scale up on the even denser foliage characters that would show up later in the film's production.

Figure 1: The optimized sim setup for Fern. ©Pixar.

3 RIGID BODY AND HAIR BASED FOLIAGE

The most challenging designs in our Earth cast featured foliage and tree trunks that accounted for a majority of the characters' silhouettes. These characters have hairdos with complex arrangements of flowers, twigs, leaves, and occasionally entire trees growing from their scalps. To ensure efficient simulation and achieve our desired asset requirements, we used procedural tools to generate foliage that hit the visual markers of the film while also keeping the foliage as performant as possible. Our procedural network generated the final render meshes of the character, as well as the optimized simulation meshes, curve networks, and arbitrary custom data to be used later in simulation constraints and shading. The additional data generated by this unified network meant that any alterations to the render mesh would instantly alter the underlying simulation setup as well.

This procedural foliage network was also designed with art directability in mind, inserting several points along the process where the artist could sculpt and groom parts of the foliage to achieve a desired look. This method of creation allowed us to iterate quickly, and even expand the cast of characters from our original designs.

4 HOUTASK

The simulation of the foliage setups relied heavily on our newly created houTask process, an extension of our existing Bsim framework. This framework packages data from our animation tool, Presto, and runs it through our internal simulators (Fizt2 for cloth and Taz for hair). The houTask enables us to send data to a custom Houdini network in the same way. This opened up the full capabilities of Houdini's many deformation options to our simulation artists, while still keeping the simulated cache data within the familiar and easily-to-evaluate context of a Presto session. Through this pipeline, we were able to create a per-asset Houdini template for each character's foliage to be simulated, and the vast majority of heavy assets were able to use this process in our shots with little additional work required.

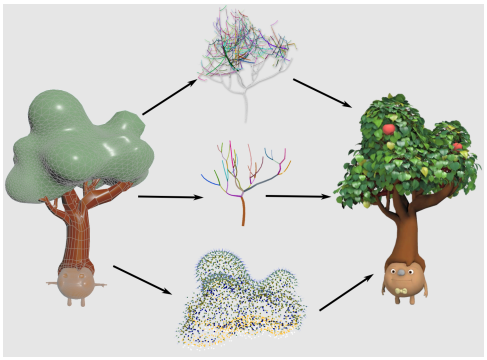

Figure 2: Procedurally Generated Tree Components. ©Pixar.

For the few shots that featured complex foliage interactions, sim artists with more comprehensive Houdini experience were able to hop in and expand the default capabilities of the character's sim template to hit our desired motion. While we were unable to give the animators direct instant feedback on these dense tree simulations for such shots, the houTask's integration within presto means that we could build a more robust template and empower animators with even more detailed feedback on future shows.

5 GARMENT CONSIDERATIONS

For many of our smaller characters, we had the additional challenge of torso garments worn over bodies that were covered in dirt and pebbles. The exterior layer of dirt was a dense particle placement using our Weave render-time deformer. The render-time approach for dirt gave us a massive performance benefit, but we were left with a collision body of inaccurate thickness while we ran cloth simulations in Presto. By baking down a height map of the render-time particle placement back into our collision meshes, we were able to get a more accurate body surface for simulation while maintaining high asset performance.

6 FUTURE STEPS

The approach for foliage was very successful for our team, but this workflow is still in active development. It took time to adapt to our new houTask process, and we believe that adopting a standard library of simulation HDAs to contain commonly used networks would help us expand this workflow to new team members in a quicker manner.

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