Elemental Characters: Bringing Water to Life

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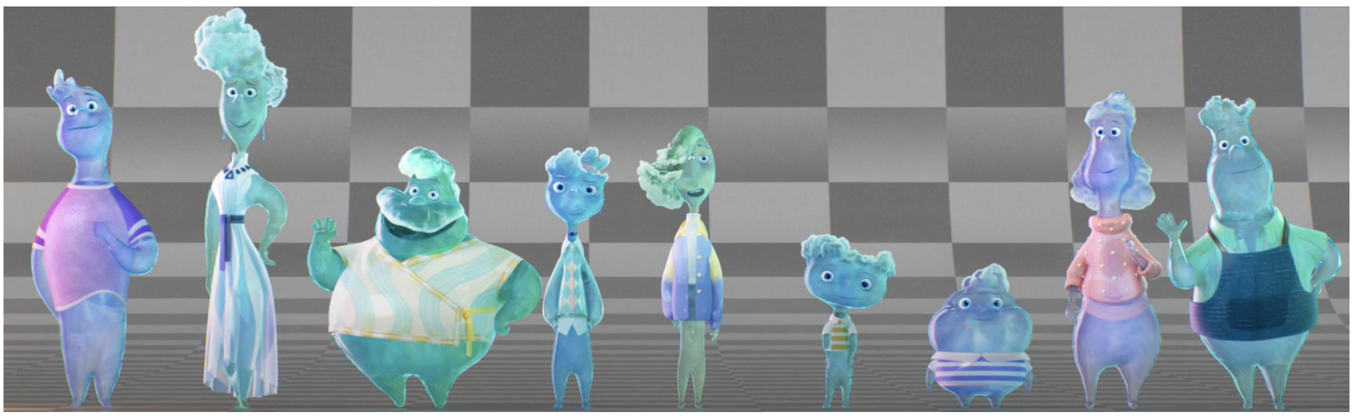

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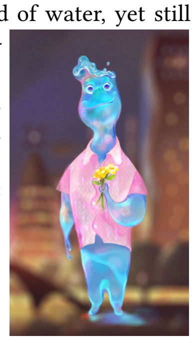
ABSTRACT

In Pixar's *Elemental*, the water characters of Element City are not drenched in water, but made of the element itself. Our goal was to create characters that felt non-human and of water, yet still maintain design, readability and charm. Starting with the concept art (inset) and at every step of the modeling, rigging, simulation, shading, effects and lighting for the water characters, we balanced the characteristics of water with the more traditional goals of character design: water's evolving shapes and dynamism with iconography and clean silhouettes; its complex light interactions with a focus on the emotion of the acting and readability of features.



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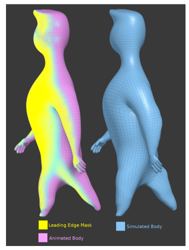
1 MODEL/RIG

To embody the dynamics of water, in addition to downstream simulation, Wade's fluid movement needed to be driven by animation in directable performance. We started with a model that was simple in shape and topology, allowing for extreme changes to its form. Wade's model adheres to a design stripped of indications of a rigid internal structure like bones or musculature and consists of smooth curved forms which may be deformed into any shape needed. This required many rig features including smooth shape language and articulation, soft and broad articulation to achieve the flow of gesture and appeal, shaping controls with bulges in the limbs and torso, and shaping curvenets for localized edits [Nguyen et al. 2023]. For extra wateriness, we added kingpin to loosen facial features, animated ripples, hair rig, and controls to inform effects downstream.

2 SIMULATION

Tetrahedral meshes simulated with our proprietary solver *Fizt2* added looseness and overlap to the water characters' bodies and limbs. The material properties were stiffer toward the core and looser at the surface. The rest state was animated to match the character's posing. Per-point springs attracting the simulated points to the original animation were used to limit simulation to certain areas. We employed volume fibers [Kim et al. 2019] to increase the stiffness along the lengths of limbs and the torso, keeping them from becoming too stretchy. To keep the body feeling loose in quiet moments and break up the overlap shapes, each character's simulation used a noise field that flowed from head to toe. For occasional dramatic rippling motion, procedurally animated noise was added to the simulation's rest state. For Wade, we added a "mask" that stiffened the material properties and more closely tracked the meticulously animated leading edges of his silhouette (inset). In Houdini, we calculated the facing ratio of each point's normal relative to its velocity. Points that were oriented in the direction of motion received a high value, which was transferred onto the interior tetrahedral mesh points and faded off over several frames.



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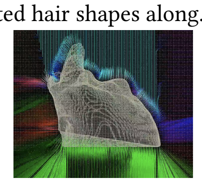
3 EFFECTS

From early designs, the hair was the area with the most water dynamics. We thought of the static hair model as a moment in time capturing an impression of the silhouette. We procedurally modeled shuffling hair shapes to act as rolling waves, in some instances using a Poisson solver which generated a smooth surface attribute that interpolated the endpoints [de Goes et al. 2020]. Another in-house tool was also used to generate streamlines following the gradient of the interpolated attribute, which we animated hair shapes along.

In a sim space, we ran a Houdini FLIP simulation with pre-calculated forces in along the SDF gradient, out towards "escape windows" at the peaks to act as crashing waves, and down along gravity (inset). Post simulation we created a topologically consistent mapping of the procedural mesh using the method of [de Goes and Martinez 2019] that deforms the simulation to match animation silhouettes. For crowd characters we adapted the look for 30 variants from 7 base models and ran a light-weight pop sim instead of FLIP.



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Our pipeline is based on a new version of *hexport*, the automated houdini export system developed for Pixar's *Soul* [Coleman et al. 2020]. We can now execute arbitrary ROP graphs to run simulations, and override per shot HDA's and individual USD backed parameters. This allowed complex and targeted shot-work, such as Wade turning himself into a literal wave at Air Stadium.

4 SHADING

A number of strategic design choices as well as shading, lighting, and rendering techniques were employed to simplify the water. Physically correct materials added lots of distracting reflections and refractions, making it difficult to read facial expressions and poses, and impossible to hide internal geometry (inset's right side). The design of the water characters was simplified by adding murkiness, which reduced refraction and allowed for a stylized, volumetric "pool caustic" effect (inset's left side). To provide shaping and additional color complexity, a faked light source with a rough specular response, called "Gleam", was added. Line art was used to preserve and emphasize the character's silhouette and key facial features. In addition, we only distorted light paths on the first bounce, combined a sharp and a rough refraction lobe, and used an extra N dot L term to attenuate highlights on camera-facing surfaces. Internal details such as bubbles and caustics were dimmed near key facial features. Light Path Expressions were used to drive the visibility of internal geometry like eyes and teeth. Given how heavily the look of water depends on its environment and light sources, the boundary between shading and lighting on *Elemental* was even blurrier than usual.

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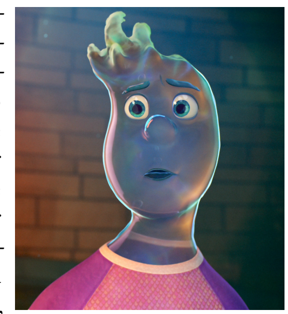
5 LIGHTING

In lighting, we were tasked with making water characters "on model," watery, and integrated into the environment, all while maintaining a ratio of 60 to 40, realistic to stylized. The murk, caustics, refractions and hair foam were more realistic, while the bubbles, gleam, reflections, specular highlights and the coloring of shadows were more stylized. We would manipulate the shadows, reflections, refractions and overall color of each element to try and simplify the characters and preserve their appeal.



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These goals were especially challenging with physically based rendering and lights, as we could not solely rely on the lighting rigs in the scenes to influence the characters. Set lights would cause characters to get lost in reflections and refractions. We therefore had to use a special lighting system designed just for the water characters to make them more appealing, stylized and art directable. In the final rendered image above, Wade is lit to match the darker subterranean environment he's in. Shading networks were heavily customized per sequence and per shot so the characters could become the water chameleons they are.

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