Procedural Techniques for Large, Dynamic Sets in *Elemental*

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ABSTRACT

The world of Pixar's film *Elemental* is inhabited by characters made of fire, water, air and earth, and we needed to give these characters a home that was just as dynamic as they were. Specifically, we needed to build a city with new and distinct forms of architecture for each element, fill this city with fire, water, smoke and vegetation, and add animation to make everything feel alive in the way a bustling city should. In this talk, we present our techniques for handling problems of scale, such as parameterized building generation and dressing, application of a variety of fx elements within large sets, as well as some novel approaches for automated color palette generation, both in an asset and shot context.

KEYWORDS

environments, lookdev, production design, houdini, proceduralism

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1 PALETTE BASED SHADING

Fire Town is a large city in Elemental consisting of stylized buildings for fire characters. The building shapes are very distinct from past Pixar films, and the number of Fire Town building designs was relatively limited. One way that we added variation was by shading the instanced buildings using an image-based color picking approach, where the palette of the city was generated from one or more input images. One of three materials is assigned to each part of the building prototypes. For example, ConcreteA is assigned to the facade, ConcreteB is assigned to the roof, and ConcreteC is assigned to moldings. Three color values are sampled from a palette image and stored as primvars (BuildingColorA, B, C) in each instance that are used as albedo in the materials. In this way, each building instance could be shaded with different colors even though they share the same prototype. This process allowed for an intuitive workflow where an artist could control all the building colors by manipulating a single palette image.

Furthermore, we created a tool for the lighting department that allowed them to reassign the local color of assets in a shot context using spatial modifiers, point clouds, or shading signals. This allowed the lighting department to utilize the palette shading approach on any assets, or blur local color across models, while still maintaining the material properties established during shading. This technique proved very useful in simplifying the visual detail in certain parts of the frame.

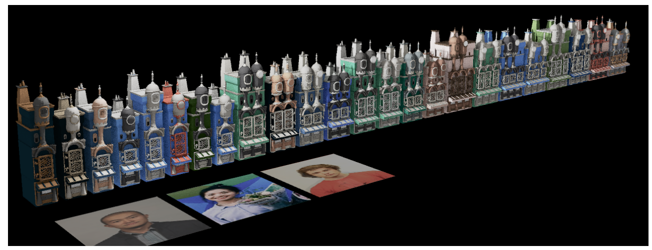

Figure 1: A section of procedural city with a palette based on the images of the three people below. ©Pixar.

Figure 2: The left image represents how this set was shaded as an asset. The right represents local color overrides using spatial modifiers. ©Pixar.

2 BUILDING GENERATION

Even with color variation, the repetition of shapes in Fire Town buildings was still recognizable. To address this, we created a modular system by breaking the existing building designs into parts such as base, center and top, each of which had multiple variants such as narrow, normal and wide, which were procedurally assembled into a wide range of combinations in Houdini. Rooftop props such as chimneys and fire ovens were used to make even more variations of the skyline.

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Figure 3: Examples of city shots featuring some procedurally modeled and shaded buildings. ©Disney/Pixar.

Element City is an even larger, sprawling city full of unique architecture for water, earth, and air characters. To fill out Element City with enough variety, we created procedural, parameterized versions of several building designs that matched the style of the hand-modeled foreground buildings. These were created in Houdini, combining a number of procedural modeling techniques in SOPs with instancing of existing models using Solaris. For example, we created procedural apartment buildings that arranged apartments in phyllotactic spirals around different building shapes and silhouettes. We also created apartment buildings based on molecular structures, by converting Protein Data Bank (PDB) files for various molecules into procedurally generated geometry that aligned with the atoms and chemical bonds.

Finally, we developed a system for art-directing the silhouette of the city skyline, in order to create stylized, wavy shapes. An artist could create 2D curves that were mapped onto different sections of the city, and the corresponding buildings would shift vertically to line up with the silhouette curves.

3 ASSET LEVEL FX AND ANIMATION

Most buildings in Element city included animated components in order to make the world more dynamic and tied to the elements, such as windmills, water, and sequins blowing in the wind. We created multiple strategies to build animation into assets and avoid the need for per-shot intervention, by leveraging workflows supported by Pixar's Universal Scene Description (USD). First, we allowed sets artists to animate models by keyframe animation in Maya or procedurally in Houdini. Our model build process would automatically

Figure 4: Final vivisteria flower design. ©Disney/Pixar.

create a USD value clip when time samples were found. Then, each shot would automatically offset all the clip times so that a random section of the animation played over the course of the shot. Manual timing overrides could be done using a new interactive workflow in Houdini. Second, we created animated shaders that resembled water flowing down a surface, which were spliced onto a subset of the building models as a clearcoat layer. This could also be adjusted per shot or sequence in the rare cases that were needed.

In addition to the city, our film also has a unique flower called the Vivisteria that we see bloom. Our goal for the vivisteria was to create a flower that felt special and unique in both its final form, and during the bloom animation, but still maintained some recognizable touchstones of a flower. To achieve this, we utilized Houdini as a rapid-prototyping tool to quickly mock up ideas and create a tool specifically tailored for editing flower bloom animations without the need for rigging. For the layout of the flower, we create a series of points arranged in a phyllotactic pattern representing the petals. Each point contains information such as petal orientation, stamen length, deformation level, and time offset. With this information, we procedurally named each component in the flower structure, and created a large variety of modeling variants, as well as signals for shading variation across models. Similar to the animated buildings, this flower's animation was defined at the asset level with a USD value clip, which was offset and retimed in shots to add variation.