Hair Effects in Trolls World Tour

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Figure 1: Examples of various hair styles and hair effects in the film Trolls World Tour

ABSTRACT

The world of hair in DreamWorks' film *Trolls World Tour* got much bigger than in the first film *Trolls* [3]. The distinct musical genre that each Troll tribe was devoted to, influenced their hair design and movement. The wide variety of hair effects, both passive and active, exhibited by the Trolls in various environments and situations, provided interesting challenges. This talk presents the techniques used to bring that expansive world of hair to life.

CCS CONCEPTS

• **Computing methodologies** → **Physical simulation**; **Procedural animation**; **Shape modeling**; **Collision detection**.

KEYWORDS

hair, fur, grooming, motion, simulation, collision, wind, effects

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1 INTRODUCTION

In the film *Trolls World Tour*, the main characters *Poppy* and *Branch* discover that they are one of six different Troll tribes scattered over different lands. Each tribe is devoted to a different genre of music: Pop, Funk, Classical, Techno, Country, and Rock. The wide variety of their hair styles and environments influenced their hair motion. Hair took many forms such as underwater hair, hypnotizing hair, lasso hair, flight hair, dancing hair, and hair that contains characters. A custom hair motion template was used by *Character Effects (CFX)* artists to simplify and unify the dynamic motion setups for these numerous hairstyles. Camera-based screen sculpting and sketching tools were developed to hit artistic shapes in motion. A high level of user control, including per frame curve vertex control, over animated hair styles and render hair motion was built into DreamWorks' proprietary hair generation library *Willow*.

2 MOTION INFLUENCE BY MUSIC GENRES

The different music genres that the Troll tribes adhered to influenced their hair styles and motion. The Techno Trolls lived underwater and their hair was made of bioluminescent fibres. All of their render hairs were simulated. A custom post-simulation temporal smoothing filter was built to create the underwater effect. The Classical Trolls hair, looking like a nobility wig, moved as a whole and hair-to-hair constraints were built to maintain its shape. The Country Trolls hair had curls which needed to be broken up during motion while maintaining the volume of the hair. This was achieved by picking and choosing hero curls to have different simulation settings. The Smooth Jazz Troll's hair needed to

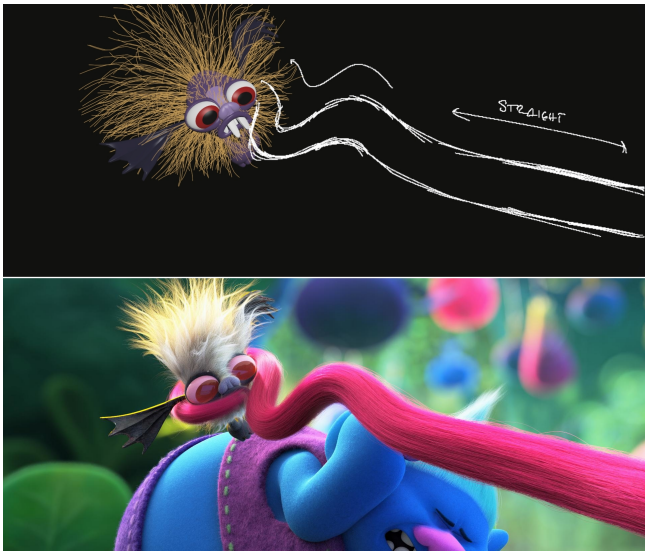

Figure 2: Drawovers from Animation indicating hair shape during the grab, imported into the 3-D package using the ImportDrawOver tool for work by CFX (Top). Hair shape achieved by sketching the control curve in the viewport using the screen space SketchCurve tool (Bottom).

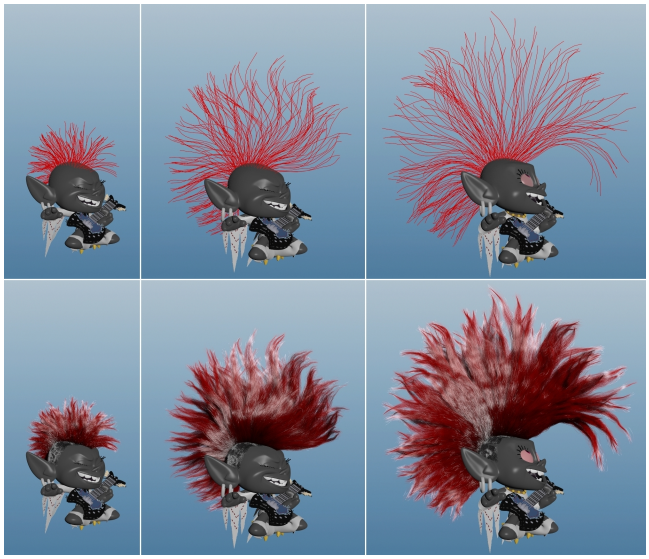

Figure 3: Screen sculpting of Barb's guide curves through the transition from start shape to end shape (Top). Corresponding final render curves with stylers animated (Bottom).

be hypnotizing and magical. Ambient wind capability was added to custom procedural wind nodes to produce long hair movement with a mesmerizing wavy effect. Rock Trolls hair was wild and grungy. Imbuing a rebellious nature, the hair loosened during fast motion to enhance the untamed headbanging, and snapped back to stiff during regular motion commanding your attention like a power chord. Funk Trolls hair had more motion to go along with the strong rhythmic groove. They had dreadlocks each of which were made up of multiple curves that needed to be constrained to one another in order to maintain the shapes. Funk King's head hair was a hybrid of both hair, and mesh geometries driven by simulated center curves. This mash-up on one head paid homage to funk's variety of influences, such as, jazz and soul.

3 ANIM TO CFX : ART DIRECTED HAIR

In several shots in the film the hair needed to achieve unique and interesting art-directed shapes. These specific shapes were provided by *Animator's* drawovers on top of rendered movies.

A custom *ImportDrawOver* tool was written to import those drawovers into 3-D packages for *CFX* artists to address them. *ImportDrawOver* tool took anything drawn on top of render takes, and extracted those drawings as a layer with an alpha channel. Artists were able to import this layer and attach it to the shot camera for viewing purposes. By adjusting the plane that the drawing was on in camera space, it allowed for an over or under composition to get exact silhouettes, and timing. This visual communication of the *Animator's* intent through drawovers eased and sped the often iterative process of translating *Animation's* intent into actual shapes in *CFX*.

A custom *SketchCurve* tool was developed that allowed artists to draw curves in the 3-D viewport in screen space to hit the drawovers. This tool had several features such as length preservation (if needed), forward and backward sketching, partial curve sketching, uniform curve segment length sampling with length changes (if needed), undo/redo sketching ability, and keyframing capability. Since the same 2-D curve positions on screen space can be obtained from multiple 3-D curve positions, the tool also provided two screen space projection modes, (1) to maintain the original depth from camera of each affected curve control vertex (CV) while sketching, and (2) to project the CVs to the depth from camera of the first closest chosen CV for sketching, essentially flattening the sketched part of the curve to the camera plane passing through that first chosen CV. Also, a custom *Z-Depth Push* tool was built to push points (if needed) in positive or negative Z-depth relative to the camera without changing the screen space shape.

As *Poppy's* hair wrapped around the *Hard Rock Bat messenger* (Figure 2), the *SketchCurve* tool allowed for detailed adjustments to get the squeeze feeling tight in its grasp, and to create waving shapes that were redrawable per frame. This made addressing notes for specific shapes very fast. With that hair path laid in, the bat was worked on for contact, and then the shape of the original hair path tweaked again with *SketchCurve* to make the contact, without collision simulation, feel right.

Custom Camera based shot-sculpting tools including screen space brushes and screen space lattices were built and that allowed hitting silhouette shapes with ease. Barb's final hair transformation (Figure 3) used screen sculpt tools to manipulate the curves per frame in the viewport to create a feeling of an overlapping motion from the fast growth from her scalp. This clay-like screen sculpting was applied to the blended frames between two different sims (one for her short hawk, one for the extra long hawk). Because both of her groomed styles were created with this transformation in mind, the CFX artist was able to blend the same guides from one groom to the other.

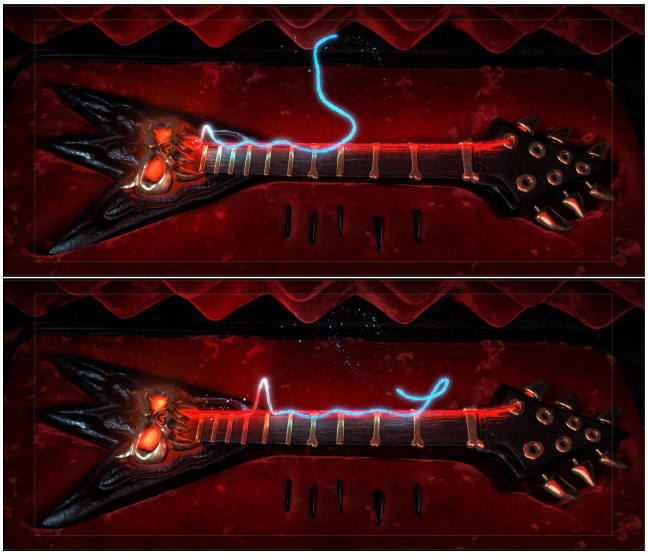

Figure 4: Magical guitar string animated by the SketchCurve and Z-Depth Push tools

Figure 5: Helicopter and parachute hair indicated by Animators (Top). Hair curves by CFX artists (Bottom).

Parachute hair (Figure 5) utilized these tools to match the timing and shape given by *Animation* in combination with procedural animation and animated stylers. Apart from hair, *Barb's* guitar strings (Figure 4) were also similarly animated as they magically installed themselves onto the guitar. Along with the *SketchCurve* tool, the *Z-Depth Push* tool was used to offset the guitar string in relation to the camera in order to keep it in the correct 3-D space, especially for close-up shots with camera movement.

Animated geometry shapes such as helicopter hair (Figure 5), dancing hair legs (Figure 6), and mustache lasso were also provided by *Animators*. *CFX* artists used those shapes to drive the hair growth volumetrically through the rest geometry shape, and then custom wrapped the hair to the animated geometry shapes. The helicopter hair (Figure 5) used the animated shapes for spin timing after the hair blades were procedurally sculpted to match art reference.

4 SIMULATION SETUP

Given the numerous hair styles, it was imperative that the template for hair simulation setup be refined. This allowed the artists to move from character to character with ease, consistency, and familiarity. The hair template contained hair solver presets that could be applied for a quick simulation setup during development and during shots. Versioning of simulated results enabled cache blending techniques, and allowed quick visualization of prior simulations, which in turn sped simulation iterations. The hair template allowed the artists to visualize the final render hairs in the 3-D viewport (using *Willow*) and make Styler edits based on the motion in shots, and/or tweak motion based on the final render hairs. The hair simulation setup also provided pre-simulation and post-simulation capabilities. The artistic hair shapes could be introduced into the simulation as rest shapes or pose shapes. The *Whip*[2] solver dynamics organically modify those shapes. A custom *CurveSmooth* node that maintains relative curve segments lengths during smoothing was used to spatially smooth the curves (if needed) to get rid of undesired shapes in simulation. The artistic hair shapes could also be achieved post-simulation using a wide variety of hair sculpting tools described prior.

Funk hero characters such as *Cooper* variants, *Queen*, and *King*, used a custom *CurveJiggle* tool to produce secondary motion on the body fur instead of a full simulation to optimize performance. The *CurveJiggle* tool rotates and bends the curve segments based on a spring simulation tracking the animated tip point (or both the tip and the midpoint for a softer motion), and can robustly and quickly handle tens of thousands of curves. *Regatonne* Trolls, used a cloth solver for the motion of their hair which was represented as mesh geometry. *Skunk* [1] was used on creatures such as generic *Funks*, *Buffalos*, *Jazz birds*, and other furry characters to produce motion on the fur, including custom procedural wind with collision, shielding, and gusts.

5 STYLE AND RENDER CURVE CONTROL

As the hair changes shapes in shots, the stylers used to create the render hairs such as *Curl*, *Kink*, etc needed to be modified to maintain the silhouette and shapes. *Willow* provided the ability to animate those hair stylers per frame, per render curve in shots. For example, when a hair with kinks is used as a lasso to grab something, it stretches and straightens under the pulling force. The *Kink* styler amplitude is animated and reduced to reflect the tension in the hair. For *Barb's* Mohawk hair transition (Figure 3), the styler's values weren't exactly the same between the initial and final pose grooms, therefore *Willow's* ability to animate *Kink*, *Clump*, and *Contract* stylers post groom was utilized to blend those for a matched look.

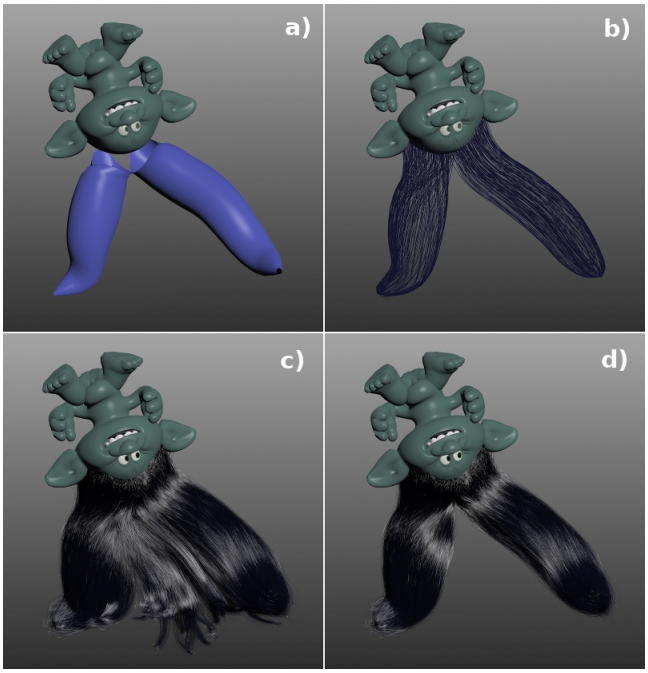

Figure 6: a) Animated dancing legs' hair tubes b) Guide curves volumetrically grown through the tubes and tracked with animation, c) Final render hair, with the original hair groom styler setup (without interpolation breaking control between the two legs' guide curves) causing an artifact, d) Final render hairs, with shot level dynamic interpolation breaking control.

Willow also provided the ability to remove existing stylers or add new stylers to the styling chain in a shot.

The interpolated hair needed to split for effects like dancing legs hair. A custom *Interpolation Control* styler [4] was used to provide interpolation breaking control in shots. Even though the original hair groom's render hairs originally might have been setup to interpolate through all the guide curves, the guides can be dynamically split into interpolation groups in a shot, and have them only interpolate within each of the those groups using that styler. For example, in the dancing legs hair shot (Figure 6), the guide curves are split into two interpolation groups dynamically (one for each leg) to avoid hairs interpolating between the two legs when they separate during dancing. Also, any cross clumping (caused by *Clump* Stylers) of render curves between the different groups is auto detected and turned off during this interpolation break. The interpolation grouping and breaking control was provided both at the curve level and the curve CVs level (if needed for example to break interpolation only in a certain lengthwise section of the hair).

A *Contract* styler was used to produce effects like hair cutting, hair shrinking, and hair shaving. This styler can be used dynamically in a shot to contract chosen render curves along its length.

A custom *ReplacePosition* styler was used to promote any set of styler generated render curves to hero curves, whose positions could then be modified by the artist and replaced back in shots. This allowed full animated artistic control over the final render curve shapes. This was very powerful as the final render curve positions in a shot can be completely controlled by the artist irrespective of what the stylers originally produced. Apart from being used to control artistic shapes at render curve level, this styler can be used to replace rogue render hairs and control flyaway render hairs.

6 IMPLEMENTATION

The various tools and techniques used to create the variety of hair effects were implemented in a node-based procedural third party package. The various custom built nodes are multi-threaded and implemented in C++ and the third party's expression language. The different motion tools can be layered one on top of the other in different ways and used to produce various effects and artistic shapes, and/or used to reduce or remove artifacts. This made the techniques versatile and adaptable, blurring the boundary between dynamic simulation and art directed motion. The ability to control and modify the groom during motion unified the hair's motion with its look. The tools brought together the *Animators* and *CFX* artists by improving communication and speeding up iterations.

7 DISCUSSION AND LIMITATIONS

Currently a *SketchCurve* node can be used to sketch only one curve. Adding ability to sketch and animate different and/or multiple curves during each sketch stroke will improve its capacity. Also, currently a *ScreenSculpt* node works on the whole set of incoming curves. Adding a feature to select and sculpt different curves and/or multiple curves during each sculpt stroke would improve its fidelity. Editing, adding, removing, and animating render curve *Willow* stylers in a shot was a manual and technical process on *Trolls World Tour*, which needed expertise, and having a robust user friendly interface to help with that would have been helpful.

8 CONCLUSION AND RESULTS

The influence of various music genres on hair styles and motion vastly expanded the world of hair in the film *Trolls World Tour*. *CFX* artists worked on about 1600 shots with hair motion. There were 79 distinct hairstyles, 64 unique hair simulation setups using *Whip*, and about 20 secondary hair motion setups using *Skunk*. The challenges of creating all the hair effects brought together a combination of consistent hair simulation setups, an optimized fur simulation toolset, a suite of art-driven and artist-friendly hair manipulation tools, an effective communication link between *Animators* and *CFX* artists, and a high level of dynamic control over hair styles and render hair deformations. The technical and artistic hair challenges imposed by the film pushed the boundaries of art-driven hair and the tools used to create them.

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