

Hierarchical Controls for Art-Directed Hair at Disney

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Figure 1: Hair Hierarchy. Left) Groom Hierarchy level 0 and level 1. Middle) Hierarchical sculpting tool (thick curves are the control curves) level 0 and level 1. Right) Result of post-sim hierarchical sculpt (inset: original simulation result), rendered result.

ABSTRACT

Creating appealing shapes and silhouettes of a character’s hair while maintaining the organic motion produced by physical simulation is a challenge in Disney’s very stylized animated worlds. This talk describes the introduction of hierarchical sculpting controls into our hair pipeline and presents a set of tools for creating and manipulating this consistent structure to achieve art-directed hair motion. From grooming through animation, simulation and technical animation, hierarchy is leveraged both for efficiency and for preservation of the hairstyle’s structure. To date this hierarchical workflow has been used on two feature productions, allowing for the efficient art-direction of a wide variety of hair types and styles.

CCS CONCEPTS

• Computing methodologies → Animation;

KEYWORDS

hair simulation, animation, deformation, hierarchical methods

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1 INTRODUCTION

Art-directed posing and animation of hair remains an open challenge in 3D animated productions. There are many instances where the shape, silhouette, and motion of hair is important to the overall character design and story. Visual development artwork capturing

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many different views and poses informs the development of the 3D groom. Similarly, in animation, *2D drawovers* communicate the desired behavior of the hair under motion.

In our production pipeline, the process of crafting a character’s hair begins with grooming. An artist creates specific shapes and silhouettes which capture the look and structure expressed by the character design. The output of the grooming process is a set of curves (represented by a single custom *multiCurve* shape), and a scalp clump map defining the base organization of the hairstyle/groom.

The hair rig is then created based on the groom curves and clump structure. Due to the large number of curves and the complexity of behavior, physically-based simulation approaches are used to produce realistic hair motion. The hair rig consists of a set of controls and maps defining material properties, and any additional constraints, etc. that are necessary as inputs to the simulation in order to achieve the desired motion behavior while also maintaining the hairstyle. It is often not possible for highly stylized performances to hit the desired hair shapes by adjusting simulation inputs alone. The technical animation artists employ two main techniques in these cases: pre-simulation posing of target shapes to drive the simulation through goaling, and post-simulation direct sculpting of the output curves.

This talk describes the introduction of a hierarchical control workflow into our hair pipeline, providing a through-line from groom to animation, simulation, and technical animation. This control structure, when coupled with a set of tools for creation and editing, aids in preserving the integrity of the hair style in motion and achieving the desired art direction.

2 TOOLS

2.1 Grooming

Our in-house grooming tool allows for the creation of clumps of hair, represented by tubular surfaces, that correspond to particular regions on the scalp of a character. Artists often work coarse-to-fine by first defining a small number of large clumps that roughly define the general shape of the groom, and then subdividing the clumps to add detail. This process of progressive refinement continues until the desired level of shape detail is achieved.



Figure 2: Left) Groom tubes, output curves and clump map. Right) Post-sim sculpt to restore stylized silhouette (inset: output of sim).

This grooming tool, first developed on *Frozen*, has been used on a wide variety of hairstyles and productions. Initially, the hierarchy implicit in this coarse-to-fine workflow was transient. In the current workflow, the hierarchy is explicit and a first-class component of the grooming process. The clumps produced by subdivision are assigned as children in a persistent hierarchy to their original coarse parent. The two coarsest levels of a groom hierarchy are illustrated on the left in Figure 1. The hierarchy provides efficient construction of the groom, as well as a means of capturing the desired structure to be passed to subsequent departments.

2.2 Sculpting

The ability to sculpt and manipulate hair curves is an integral part of the simulation/cleanup process. Deformation of a large number of curves has typically been a bottleneck in our Maya-based hair pipeline. In addition, it was difficult to efficiently achieve the desired hair shapes with the available curve deformers. The result must not only match the art direction, but for the pre-sim goal shapes, curves must also be well-formed as inputs to the simulation. This involves maintaining constraints such as hair length and volume.

To address these challenges, we developed a hierarchical length-preserving deformation algorithm which produces smooth, predictable shapes, and leverages the groom hierarchy to help preserve the desired structure and volume. An intuitive interface built on top of the hierarchical deformation algorithm allows for a fluidity of coarse-to-fine posing. The middle images in Figure 1 show the curves in the sculpting tool. The thicker curves, which are the parents in the hierarchy, are used as control curves to sculpt at varying levels of detail, while the child curves maintain their length as well as local structure with respect to the parent.

3 WORKFLOW

The hierarchy created during the grooming process can be directly consumed by the hierarchical sculpting tool. A cleanup shape annotated with the hierarchy information is incorporated in the base hair rig. Similarly, the hair rig is structured to allow goal shapes to be created as needed on a per shot basis. The artist can then use the

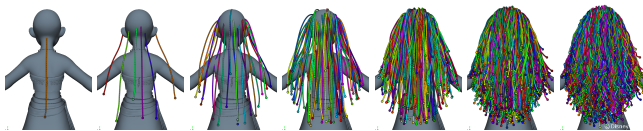


Figure 3: Seven level control hierarchy for a loosely structured style.

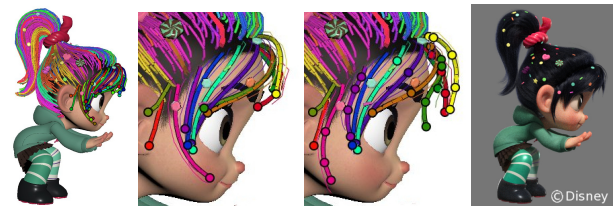


Figure 4: Left) Simulation Rig with single level for the bangs. Middle) On-the-fly parent control levels are used to make a hierarchical edit. Right) Render.

hierarchical sculpting tool pre- or post-sim on the goal and cleanup shapes. Parent control curves are constructed recursively, by averaging the output curves from simulation, bottom-up. Figure 1 Right illustrates the results of a post-sim edit utilizing the hierarchy at multiple levels to hit the desired shape.

The edit in Figure 2 uses a two-level hierarchy. In this case, the simple structure is well-suited for the hairstyle, allowing the distinct hair tufts to be edited as a unit, and for the individual hairs to break apart when needed. Figure 3 illustrates a more complex hierarchy for an organic groom. The hierarchy is powerful for efficiency purposes even in unstructured hairstyles as stylized shapes are still required.

3.1 On-the-fly Hierarchy

In shot work it is often necessary to add specific shapes and structure to a groom based on the desired performance. In these instances, it is possible to create on-the-fly hierarchies either by adjusting the groom hierarchy or by creating an entirely new structure. Shot artists can arbitrarily group and edit the hair curves by simply selecting a subset of curves and a parent curve is then generated on the fly procedurally. Figure 4 illustrates an example where the bangs have no pre-defined hierarchy levels in the groom. For shot-specific posing, the artist injects one level of hierarchy interactively. This hierarchy may be transient, if only needed for one edit, or made persistent across the shot/sequence as needed.

4 PRODUCTION RESULTS

This hierarchical hair workflow was first introduced on *Moana* for three of the main characters and was successful in providing an efficient means to achieve the art-directed hair shapes. For the current feature in production, *Ralph Breaks the Internet: Wreck-It Ralph 2*, many of the grooms thus far (including main and crowd characters) have been designed with persistent hierarchies. Previously, this sort of control structure would have to be constructed in rigging for each character and hairstyle, and in practice this was only done for special cases. With the on-the-fly hierarchy functionality, artists can efficiently create hierarchies entirely from scratch, making multi-resolution edits implicitly available for any of the 772 characters with hair rigs, whether or not a groom hierarchy is provided. One future goal is to enhance the tool set and surrounding workflow to allow character animators and simulation artists to iterate more closely on crafting the hair performance, though the common interface provided by the hierarchical control structure. In addition we would like to explore sketch- and volume-based controls as well as spatio-temporal editing.