

Disney's Hair Pipeline: Crafting Hair Styles From Design to Motion

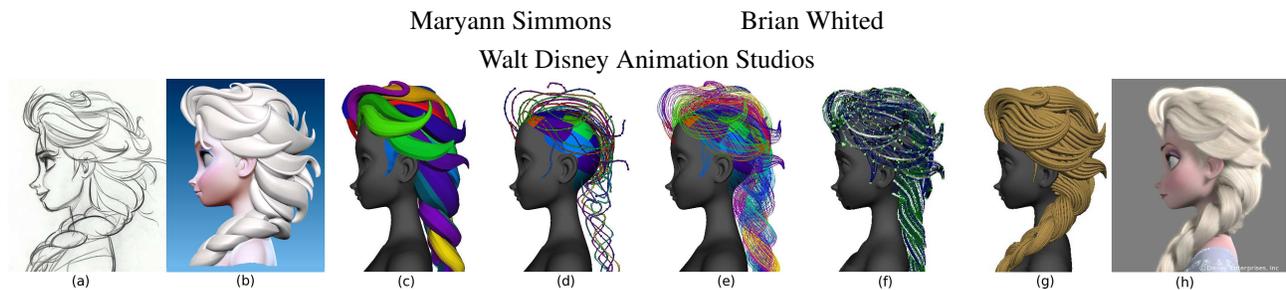


Figure 1: Previs: (a) drawing, (b) hand-modeled hair volumes. **Grooming:** (c) Tonic tubes (~50 tubes), (d) Tonic center curves and region maps, (e) guide hairs interpolating volumes (~1000). **Simulation:** (f) hair rig, (g) simulation curves (~100 sim curves, motion of guide curves is interpolated from sim curves: ~1000 guide curves). **Render:** (h) test render (~400,000 rendered curves).

1 Introduction

In this talk we will describe the hair pipeline at Disney – its evolution spanning multiple productions and its use on Disney's most recent full length animated feature, *Frozen*. Producing intricate hair styles is a challenging problem, spanning many departments. We focus on the generation of the hair groom and motion. Figure 1 illustrates key components of the pipeline for Elsa's groom, one of the many complex hair styles created on *Frozen*.

The artistic vision is conveyed through visual development art, often in the form of drawings (1a). Then, hand-modeled 3D proxies are sculpted to capture the desired flow, style, and volume of the hair (1b). These proxies can be created quickly by a skilled modeler and serve as an approximation of the look of the final groom. However, ultimately, individual hairs must be produced that populate the hair volume such that the groom characteristics are preserved in simulation. These hand-sculpted volumes are generally not suitable for this task and producing a groom that meets the stringent requirements of downstream stages is painstaking to do manually.

Even if the appropriate models can be created, many changes are made to the groom during development, and if done by hand, the entire process often must be repeated from scratch. This tedious method was used previously, but became infeasible as the complexity and number of grooms increased each production. To scale with the complexity and number of grooms, we developed new tools and workflows to support the control needed for grooming and simulation, and streamlined the process by providing a common toolset across departments. We start our more detailed description of the pipeline at the point where the 2D/3D visdev is approved.

2 Grooming

Since the human head has on the order of a hundred thousand hairs, it is impractical to design a groom at the individual hair level. We developed a new grooming tool, *Tonic*, which uses geometric volumes to procedurally groom the hairstyle. These volumes (1c) are then populated automatically with thousands of individual hair strands. There are 3 main requirements on the hair volumes: 1) complete coverage of the scalp in order to prevent bald spots, 2) no intersections at the root level, and 3) sufficient smoothness. *Tonic* is a specialized modeling tool which helps the artist easily meet these requirements.

To ensure coverage, *Tonic* provides an intuitive interactive interface for creating a 2D graph on the 3D surface of the scalp. Each closed region of the graph represents the roots of a single clump of hair. Nodes of this graph may be added, removed, or dragged across the surface during the subsequent grooming process. *Tonic* automatically creates an associated clump volume for each region which is represented by a single center-curve (1d) and a series of orthogonal planar cross-sections. The center curve and cross sections can be directly manipulated using the control-vertices to sculpt the shape and contours of the clump. Once the hair volumes are sculpted,

Tonic generates a set of *guide* curves at a prescribed density within each region that fill the clump volumes to reflect the profile of the center curve as well as the shape/extent of the tube volume (1e). For Elsa, approximately 1000 hairs were generated from the 50 volumes. Artists then use *XGen* to add additional detail like noise, curl, clumping, etc. to the guide curves. *XGen* is also used to perform further interpolation at render time to produce the final set of 400,000 hairs (1h).

The fast and intuitive interface provided by *Tonic*, as well as the editability of the scalp coverage and hair volumes at any point in the grooming process, both allows fast creation of hair grooms compatible with downstream requirements and reduces the need to start from scratch when artistic changes are required, thus greatly reducing the time needed to create and iterate on the design. This provides a smooth hand-off to the simulation department for the creation of the groom's motion.

3 Simulation

For efficiency, a smaller subset of the *Tonic* guide curves are used for simulation. These representative curves are chosen carefully - to produce a simulation that faithfully captures the groom under motion. For Elsa, of the 1000 or so groom hairs from *Tonic*, approximately 120 were used for simulation. The *Tonic* volumes were used as a visual proxy to give a general sense of what space/shape the simulated hair will occupy.

Elsa had two hair rigs, one used for animation and one for simulation (1f). The animation rig controlled the braid motion with a single IK-spline curve driven by her body animation, such that it rode naturally along in the over-the-shoulder position as she moved, without stretching/distortion. This position was used by the subsequent simulation as a target shape. The animator could also position the rig to further control its shape/motion. Elsa's hair simulation rig was made up of two levels. The first, higher-level, rig consisted of a single center curve for the braid. This allowed the simulation artist to iterate very quickly to get the desired braid motion. This single curve sim then drove the second-level, multi-curve simulation for the braid. The bangs and crown hair simulation could then be layered on (1g). The simulation itself is performed by *dynamicWires*, our custom hair solver. The resulting simulated curves are then used to interpolate the motion of the full set of 1,000 guide curves, utilizing information from the solver.

With this new workflow and toolset, the artists were able to create the almost 50 unique hair styles on *Frozen*. Complexity management was key in this success (50 volumes:1,000 guides:120 sim hairs:1000 motion-mapped guides:400,000 rendered hairs), where the more manual aspects were performed on the lower levels of detail. Just as important was the streamlined workflow and common toolset that reduced the number of iterations between departments and amount of work necessary across groom iterations.