Directing Hair Motion on Tangled

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(a) 2D Drawover.

(b) Posing with hair rig.





(c) Sim for settling/collision.

(d) Final render.

1 Introduction

State-of-the-art simulation techniques can produce compelling and natural hair motion. In creating Disney's feature film *Tangled*, physically plausible motion was important but just one foundational component. The story contains an unprecedented amount of interaction of the hair with the characters, as well as a high level of art-direction. Through 2D "drawovers" the artistic vision was conveyed in an often very detailed way - how the hair should move, and what poses and silhouettes it should hit. Simulation alone is not sufficient when such a high degree of direction and interaction is required. We describe a hybrid approach leveraging the power of custom hair dynamics with the artistic control of key-framed animation that was key to the success of directing hair motion on *Tangled*.

2 Approaches

Animation rigs give direct control over the placement of the hair and are most suitable to use when motion is not physically-based and/or difficult or impossible to hit through simulation. This approach supports fast iterations, but does not scale well due to the amount of manual input required, making it only feasible for use on a small number of representative curves. In addition, through rig controls alone, it is very time-consuming to produce animation that faithfully preserves physical properties of the hair necessary to produce natural, collision-free motion. In contrast, simulation can handle independent and coherent motion of thousands of curves, producing natural and highly complex motion. Such dynamics, however only provide implicit control and therefore are difficult to direct. In addition it is a computationally expensive approach- limiting the number of iterations practical. Thus we introduce a system of interleaving the best of both approaches on a shot-by-shot basis.

Animation Approach: Rig-based key-framed animation

is used to produce hair motion in shots calling for non-physically-based motion and/or a high level of artdirection. The specialized hair rig contains controls for



moving the hair as a whole as well as ten break-up controls that allow sub-groups of hair to be pulled out and manipulated independently from the remaining hair volume. The rig contains IK, FK, twist, and pinch operations supported at the global or on the subgroup level; the number and distribution of these operation controllers can be altered per shot as necessary. This two-tiered hair rig is used for both posing the initial positions and for creating keyframed animation of the hair.

Simulation Approach: At the other end of the spectrum are simulation-driven shots where physics primarily controls the motion. By animating external forces (constraints, collision objects,

and force fields), the hair motion can be influenced to a desired outcome. Finer level control is provided through the manipulation of simulation properties via override sets and curve maps. These maps provide localized, per-vertex control over any constraint or property in the simulation, e.g. mass, stiffness, etc., as well as a mechanism to locally animate these properties within one simulation pass.

3 Interleaving Animation and Simulation

Hair shots are first categorized as passive, animation- or simulation-driven.

Passive shots do not require any art direction or special interaction. These shots are first batch processed using a default simulation setup. The results of this pass are evaluated and the accepted passive shots are sent to the downstream department. The remaining shots are divided into two sections. For those that share a common characteristic (e.g. wet hair), a special case simulation setup is created and applied to each shot in that group through another round of batch processing. Remaining ungrouped shots are re-classified as animation- or simulation-driven and passed on for shot-specific processing. This batch processing iterates until all shots in the initial grouping are approved or re-classified.

The majority of non-passive highly-directed shots involve multiple interleaved iterations of animation and simulation, though one generally dominates. For example, shots where the hair undergoes extreme action as a whole are animation-driven, whereas if the hair motion is organic, but still needs to hit a specific silhouette, the shot is simulation-driven.

Different portions of the hair may be classified and processed separately and the solutions blended, or combined using simulation targeting. Rig-animated shots undergo a simulation iteration by creating targeting forces to pull the simulated curves towards the animated ones. This simulation layer enhances the motion by adding fine-scale details difficult or impossible to achieve by hand. The process of creating the key frame rig-driven poses itself is layered with simulation: the rig drives the curves directly- an interactive interface driven by the simulation in turn can be used to drive the rig. In this way dynamics and explicit control are interleaved seamlessly. For simulation-driven shots, the motion can be influenced post-simulation by direct manipulation of the rig or other deformers, which ride along with the simulated hairs; this allows high-level editing of the hair without re-running a time-consuming simulation.

The presented classification and interleaved animation/simulation workflow made it possible to not only achieve the desired motions with sufficient quality, but also to do it efficiently enough to meet the practical reality of production scheduling – a significant achievement given the almost 500 art-directed hair shots.

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