Dynamically Controlling Hair Interpolation

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Figure 1: ***a)*** *Art Directed Interpolation,* ***b)*** *Distance Based Dynamic Clumping, and* ***c)*** *Collision Resolution by Interpolation Breaking*

Abstract

We present techniques to dynamically control hair interpolation. This can be used to produce art directable hair shapes, to procedurally clump hair to create rich looking animated hair shapes, and to resolve interpolated render hair collisions with mesh geometry.

1 Motivation

While a human head can have hundreds of thousands of hair strands, a few hundred or a few thousand guide curves are usually used to represent that hair for simulation purposes to save time. The lower curve count used for motion poses several issues for the final render hair. The final render hairs are usually interpolated between those simulated guides with styling added. If a core curve driven approach is used, such as binding a set of render hairs to the closest guide curve, it leads to a clumpy look when the hairs move. Interpolation applied across the guide curves produces smooth looking render hairs, which lacks texture and negative spaces. If the clumps are pre-decided during grooming, it falls short of representing the natural dynamic clumping of hair in motion. Also, even when the simulated guide curves are clear of collision with a mesh geometry, the interpolated render hairs can interpenetrate the collider. Techniques such as culling of interpolated hairs leads to loss of hair and is laborious for the artist. This talk addresses all those issues by providing the artist with manual and procedural controls to dynamically control hair interpolation. These artist friendly controls are predictable, fast, and simple to use.

2 Dynamic Interpolation Control

We employ a connectivity mesh, which is a triangular mesh obtained from triangulating the root CVs of the guide curves to define triangular interpolation, which is a traditional and simple technique. Every render hair whose root CV lies within the triangle, gets influenced by the three guides, weighted by their barycentic weights by default, associated with that triangle. Our technique provides interpolation control by dynamically controlling those weights in interesting ways to solve artistic and technical challenges. A render hair is considered fully interpolated when it uses its barycentric weights for interpolation; it is considered fully non-interpolated (or fully clumped) when it uses a weight of one with its largest barycentric weighted guide curve. The weights can be controlled manually and/or procedurally per guide hair CV or render hair CV. This precise per CV dynamic control enables the artist to produce visually rich hair and solve manually painstacking cleanup work as detailed in sections below. Manual control is implemented by storing weights per triangle per guide curve CV per frame. The artist can choose clumps of curves or CVs and provide them with hair clump IDs and clump parameters such as clump value and clump falloff. Weights are calculated internally such that the interpolation would happen only between guide curves or CVs belonging to the same hair clump ID. Procedural control is achieved by passing in parameters such as distance metrics and/or collision geometry and collision parameters. The shader procedurally calculates the weights per render hair CV based on those parameters and collision geometry, if provided, at render time.

2.1 Art Directed Clumping and Interpolation

Using the simulated guide curves, the artist can manually create negative spaces in the render hairs to art direct clumping. If there are no negative spaces or inherent clumping in the guide curves, the artist can introduce negative spaces in those guide curves by choosing a subset of those guide curves as clump curves and having the rest of the simulated guide curves clump to those curves based on chosen parameters. Those specified clumped group curves or CVs are marked with clump IDs, causing them to interpolate only amongst its similar clump ID curves or CVs at render time. This maintains the artist specified clumping or negative spaces on the simulated guide curves at render time. Figure 1a shows an example.

2.2 Distance Based Dynamic Clumping

When the guide curves separate apart, the interpolated render hairs fill in the gaps, producing a continuous sheet of hair which is visually uninteresting and artificial. The artist can specify distance metrics such as minimum and maximum break distance which control when to start breaking the interpolation and when to stop the interpolation by smoothly and dynamically changing each render hair CV interpolation weight. This produces a visually rich texture to the hair as the guide curves spread apart. As the guide curves come closer together than the minimum break distance again, interpolation is procedurally turned on dynamically producing smooth looking hair. Figure 1b shows an example.

2.3 Collision Resolution

Even when the simulated guide curves are free of collision, the interpolated render hairs can interpenetrate the collision objects, which can be quite frustrating to cleanup. When a collider is passed in with parameters such as collision falloff, the shader at render time calculates collision between each render curve segment and the collider. The colliding curve CVs are then moved towards its largest barycentric weighted guide curve by adjusting its interpolation weights with a falloff along the length of the curve until all collisions are resolved. This attraction towards a collision free guide curve with a falloff provides a stable approach with minimal or no pops to resolve render hair collisions. Figure 1c shows an example.

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