



Modeling Hair using Levels-of-Detail

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Motivation

Hair modeling is crucial for generating realistic appearances of animated characters but presents many challenging problems. Several real-time applications, such as virtual environments, game development, and interactive hairstyling systems require high quality hair simulations at interactive frame rates. The high number of hair strands on the human head and the thinness of each individual strand make it difficult to simulate hair and its many interactions accurately, as well as realistically render the hair capturing intricate light scattering and self-shadowing effects.

Our hair modeling system uses level-of-detail techniques to balance the trade-off between accuracy and performance. This system results in interactive hair simulation and rendering with higher visual quality than previous techniques by placing the majority of the computational power towards the hairs that are the most significant to the viewer at a given time.

Framework

Our hair modeling scheme uses level-of-detail (LOD) representations to simulate hair. The set of representations include individual strands (the finest LOD), hair clusters, and hair strips (the coarsest LOD) and are represented using subdivision curves or surfaces.

We adaptively group and subdivide hair using these discrete LOD representations creating a hair hierarchy. The dynamic behavior of each LOD is controlled by a base skeleton. The base skeletons are subdivided and grouped to form clustering

hierarchies using a quad-tree data structure during the pre-computation. At run time, our algorithm traverses the hierarchy to choose both the appropriate discrete and continuous hair LOD representations based on error metrics.

This framework supports automatic simplification of dynamic simulation, collision detection, and graphical rendering of animated hair. It also offers flexibility to balance between the overall



LOD Representations for hair (a) strip (b) cluster and (c) strand

Highlights

- Accelerated simulation and rendering of hair through LODs
- Flexibility to model water and styling products on hair for numerous hairstyles and hair motions



Long, curly, red hair blowing in the wind.



Short, wavy, brown hair

performance and visual quality, and can be used to model and render different hairstyles.

Dynamic Simulation and Collision Detection

Each representation uses the same base skeleton to control its motion; this aids in creating seamless transitions as the hair changes from one representation to another. The skeleton model is simulated as a series of point-masses connected by spring forces that control the bending and stretching of the skeleton. The hair geometry (in any geometric representation)

then follows the motion and positioning of the skeleton as it moves from external forces such as gravity or wind.

Our collision detection method uses the family of swept sphere volumes (SSVs) as bounding volumes to encapsulate the hair. SSVs provide a tight fit to the complex hair geometry and an easy collision detection test.



Long, brown hair blowing in the wind

Choosing Hair Representations

The current representation of a given section of hair is determined based on three criteria: the hair's visibility, viewing distance, and motion. A section of hair that is occluded or outside of the field-of-view of the camera is simulated with the coarsest LOD (strip) and is not rendered. If the hair section can be viewed, its distance and motion determine its representation. As the distance from the viewer to the hair increases we move up the hair hierarchy, simulating and rendering the hair with less detail. Meanwhile, as the velocity of the hair increases, we move down the hierarchy, simulating and rendering the hair with finer detail. Each level in the hierarchy has predetermined intervals for its appropriate viewing distances and velocities.

Rendering

The rendering of hair involves anisotropic lighting and intricate self-shadowing effects that are complicated due to the thin, alias prone hair geometry. Our system takes advantage of current GPU advances to interactively compute these lighting and shadowing effects. We use texture mapping and alpha mapping techniques to give our cluster and strip representations a more strand-like appearance.

Modeling Water and Styling Products on Hair

One of the key benefits of an accelerated hair simulation and rendering system is the ability to create an interactive hairstyling system that mimics a real-world environment. Hairstyling systems typically require effects of water and styling products on hair. Our LOD system for modeling hair includes the incorporation of these influences by changing the dynamic

and rendering properties of hair in the presence of these substances. Water increases the mass of the hair, the spring stiffness, and decreases the overall volume of the hair. Styling products, though varied, typically increase the spring stiffness drastically and increase adhesion between hair sections in contact with each other.



Blonde hair (a) dry and (b) wet



Long, straight hair moving due to avatar motion.

Project Members

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Research Sponsors

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Selected Publications

Ward, K., M. Lin, J. Lee, S. Fisher, and D. Macri. Modeling hair using level-of-detail representations. *Proc. of Computer Animation and Social Agents*, 2003.

Ward, K. and M. Lin. Adaptive grouping and subdivision for simulating hair dynamics. *Proc. of Pacific Graphics*, 2003.

Ward, K., N. Galoppo, and M. Lin. Modeling hair influenced by water and styling products. *Proc. of Computer Animation and Social Agents*, 2004.

For More Information

<http://gamma.cs.unc.edu/HSLod>

<http://gamma.cs.unc.edu/HAIR>

<http://gamma.cs.unc.edu/HairWS>