Simulating and Rendering Wet Hair

Kelly Ward Nico Galoppo Ming C. Lin

University of North Carolina at Chapel Hill*

1 Motivation

Simulating the motion and appearance of hair has been an active area of research in computer graphics due to its importance for modeling virtual humans in various applications. Existing hair modeling methods have focused primarily on capturing the basic characteristics of dry hair. In the natural world, humans interact with water every day and the physical behavior and appearance of hair is drastically changed when it becomes wet.

As it is easy to observe the physical differences between wet and dry hair on a real person, it is crucial to accurately model these characteristics in a simulation. As hair strands absorb water, they become heavier, they adhere more readily with nearby wet strands, and they tend to look darker and shinier due to the presence of water. Our hair modeling system captures these influences and is able to adjust these properties dynamically as hair becomes wet.

2 Overview of Approach

Our hair modeling system relies on a *dual-skeleton* setup to capture the various dynamic properties of hair. This dual-skeleton system consists of a *global-skeleton* and a *local-skeleton*, which provide the ability to decouple global and local motions of hair, allowing us to capture additional hair motions and various hairstyles. The global-skeleton accounts for the overall motion of the hair, while the local-skeleton is positioned around the global-skeleton to model a desired hairstyle. The rendered hair geometry is positioned around the local-skeleton. Strands in close proximity with each other are grouped together to follow the same dual-skeleton system, capturing the natural clumping of strands found in nature. Circular cross-sections are defined at each node of the local-skeleton, determining the initial thickness of that section of hair. The individual strands are then placed randomly within the confines of those cross-sections.

We create a localized collision detection method that accurately identifies interactions between the hair and the body as well as among the hairs by placing *swept sphere bounding volumes* (SSVs) around the local-skeleton and rendered hair geometry. Our overall dynamics model is able to capture the intrinsic properties of dry hair and can dynamically adjust to changing physical properties as the hair interacts with water.

2.1 Adjustment of Dynamic Properties

Hair strands can absorb up to 45% of its natural, dry weight in water [L'O04]. This increased mass significantly alters the physical motion of wet hair strands. The global-skeleton controls the overall motion of the hair and consists of node points connected by soft springs. Each node point has a mass associated with it, representing the mass of the hair at that point. The mass then becomes a function of wetness, increasing until the fraction of wetness becomes 100%.

2.2 Flexible Geometric Structure

As hair becomes wet, it becomes less voluminous. Wet strands of hair in close proximity adhere with each other due to the presence of water, causing the overall volume of the hair to decrease. To account for this behavior, when water is applied to the hair, the radii of the hair sections decrease accordingly. The radius contraction is directly related to the number of hair strands in that section of hair and the percentage of water absorbed into the hair. The SSVs used for collision detection also automatically adjust their form as water is absorbed. Collision detection remains accurate and efficient in light of the changing geometric structure.

2.3 Rendering

As noted by [JLD99], many materials become darker and shinier due to the absorption of water. Hair acts in the same manner. When hair becomes wet, a thin film of water is formed around the fibers, forming a smooth, mirror-like surface on the hair. In contrast to the naturally rough, tiled surface of dry hair, this smoother surface creates a shinier appearance of the hair due to increased specular reflections. Furthermore, light rays are subject to *total internal reflection* inside the film of water around the hair strands. This phenomenon contributes to the darker appearance wet hair has over dry hair [JLD99]. Moreover, water is absorbed into the hair fiber, increasing the opacity value of each strand leading to more aggressive self-shadowing.

We have captured the interactions of light with the wet strands by varying the rendering parameters based on the amount of water present on the hair. Specifically, using standard anisotropic lighting [HS98] and hair shadowing [KN01] techniques, we make the opacity, shininess value, and anisotropic lighting contribution a function of the wetness percentage. As the wetness factor varies between 0% and 100% the parameters vary directly, creating a damped or wet look for the hair strands.

3 Results

We presented several simple yet efficient techniques for simulating and rendering wet hair. Our system is able to capture the altered motion, physical structure, and rendered appearance of hair when it gets wet. These methods can be applied dynamically to hair to model changing wetness of hair over time. Our results are consistent with the influences of water demonstrated on real hair. Figure 1 shows a visual comparison between simulated wet vs. dry hair. Please refer to the supplementary document and videos for additional images and demonstration.

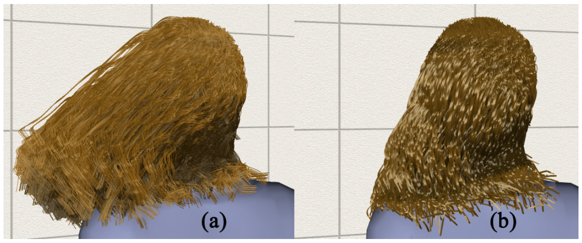

Figure 1: Long, curly, red hair blowing in the wind (a) dry and (b) wet

References

HEIDRICH W., SEIDEL H.-P.: Efficient rendering of anisotropic surfaces using computer graphics hardware. *Proc. of Image and Multi-dimensional Digital Signal Processing Workshop (IMDSP)* (1998).

JENSEN H. W., LEGAKIS J., DORSEY J.: Rendering of wet material. *Rendering Techniques* (1999), 273–282.

KIM T.-Y., NEUMANN U.: Opacity shadow maps. *Proc. of Eurographics Rendering Workshop* (2001).

L'OREAL: http://www.loreal.com, 2004.

---

*e-mail:{wardk,nico,lin}@cs.unc.edu