Modeling, Rendering, and Animating Human Hair

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Abstract

Hair is an indispensable ingredient in realizing virtual human character. In IMSC, we have developed a set of techniques for human hair modeling, rendering, and animation. For human hair modeling, we developed two techniques focusing on different aspects of hair modeling. The thin shell volume (TSV) method is suited for flat straight hairstyle where hair-hair interaction such as static charge and combing is important. Based on the TSV concept, we extend the idea of separating abstract geometry and detail. The multi-resolution cluster (MRC) model generalizes to wider class of hairstyles, such as curly hairs, short spiky hairs as well as long hairs. Incorporating physically based dynamics, we develop an interactive hair modeling system where the user can design various hairstyles assisted with physically based dynamics. This way, we minimize the enormous efforts needed to model human hair, while still maintaining the ability for fine-tuning. Rendering hair requires special methods to handle complex geometry. We develop a complete hair-rendering pipeline that takes into account self-shadows, thin geometry, and correct lighting. The resulting hair model can be used in real-time applications, such as human avatar, as well as realistic rendering for high quality images, or even for cartoon animation.

Motivation and Problems

Due to the enormous number and flexibility of hair strands, it is very difficult to realistically model human hair. However, hair is an indispensable cue for recognizing a human. For example, in a virtual avartar session, if the character does not match the hairstyle of a specific person, the avartar will fail to provide the sense of immersion.

Hair modeling is difficult due to many reasons; there are too many hair strands to control effectively. Each hair strand is very flexible. Moreover, the interactions between hairs play important roles in making some hairstyles. The thin geometry of individual hair strand necessitates specialized rendering methods to handle the aliasing problem. Also, correct computation of self-shadows is crucial to depict the underlying structure of any hairstyle.

In IMSC, we have been developing a set of methods and tools that enable the user to interactive design and manipulate hairs. Without help of the physically correct dynamics, it is often tedious and hard to achieve the desired hairstyle. Hence, we provide the user an interactive dynamics tools so that he/she can apply gravity, friction, collisions and so on, as if the user were dealing with hairs in the real world. In our system, the user first specifies the initial position and length of the hairs. Then the dynamics engine takes care of the positioning of the hairs in physically correct position. The user can interactively select and manipulate a cluster of hairs while the dynamics is running, thus getting the sense of actually dealing with the real hair.

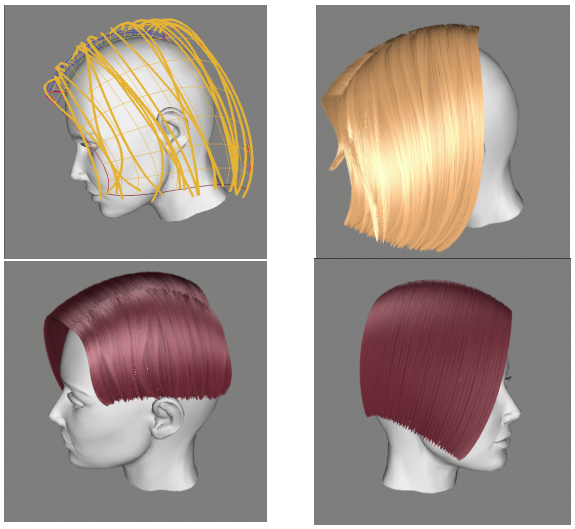
The system is still under development and current results are summarized below. The resulting hair model will be saved and imported to into the Facial Animation project.[1] The output of the system can be

[1] See also 'Human face analysis and animation research'

polygons so that it can be used for other applications such as computer games. We also plan to complete the hair modeling system as 'virtual hair salon' type of application.

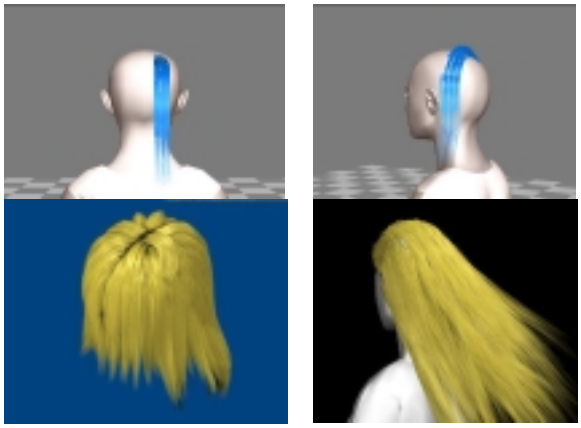
Thin Shell Volume

Fully described in [1], the thin shell volume (TSV) method is suited for flat straight hairstyle. Virtual hair combing enhances the realism by simulating hair-hair interactions that occur in real human hair.



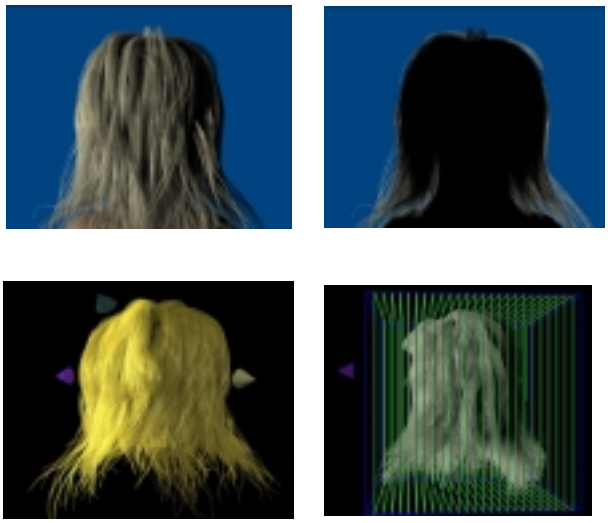
Interactive Hair Modeling with Physically Based Dynamics and Multi-Resolution Clusters

Extending TSV, we currently develop an interactive hair modeling system based on multi-resolution generalized cylinder and physically based constrained dynamics [2].



Opacity Shadow Maps and Hair Rendering

Self-shadow is a crucial part of hair property. Without correct self-shadows, the detail of the underlying structure cannot be seen. Opacity shadow maps [2] provide a hardware-accelerated solution to the shadow problem in complex geometry such as hairs.



Extensions

The hair model can be rendered in various artistic styles. Also, the short hair model easily adapts to animal furs.

References

[1] TAE-YONG KIM AND ULRICH NEUMANN, A Thin Shell Volume for Modeling Human Hair, *IEEE Computer Animation*, pp. 104-111, 2000

[2] TAE-YONG KIM, Animating hair clusters with Collisions, *To be published*

[3] TAE-YONG KIM AND ULRICH NEUMANN, Opacity Shadow Maps, *Rendering Techniques 2001*, pp. 176-181, 2001.