A Method of Human Short Hair Modeling and Real Time Animation

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Abstract

This paper describes a method of human short hair modeling and real time animation. A method is proposed to model the short hair. First, a hair style model is derived from a scalp model interactively. Then, the hair model is derived automatically from the hair style and scalp models. Texture mapping is applied to hair model for a better visual effect. For animation, a method is proposed based on an approximation of the accurate physically-based hair model, from which the 3D morphing key shapes are derived. Then, the intermediate shapes are computed by applying 3D morphing. We have implemented it and compared the results with real hair. The visual quality and frame rate are satisfactory for real time applications.

1. Introduction

Hair modeling and animation are very challenging due to the presence of a large number of hair. Almost all work is based on different physically-based models [11]. Two well-known approaches are [1] and [10]. An integrated system is described in [2], where an interactive module called HairStyler [12] is used for modeling, collision detection is performed efficiently with a cylindrical representation of the head and body [6], and responded according to the reaction constraint method [9].

The recent work includes [8, 3, 13]. In [8], a method was proposed for animating long hair while modeling both interactions between the hair and the character's body and between different hair wisps. It relies on a layered model paradigm consisting of the skeleton curve, the deformable wisp envelope, and the rendering layer. In [3], hair volume is considered as a continuum and simulated by fluid dynamics. To retrain the individual character of hair, an elaborate model was devised for stiffness and inertial dynamics of individual hair strand. In [13], a method was proposed for modeling realistic curly hair style, taking into account both artificial hair styling processes and natural curliness. The result is a detailed geometric model that can be animated and rendered by other methods. All of them have produced excellent visual results comparable to those of real hair. However, they are not specially devised for short hair and also not for real time applications.

Compared with the long hair, short hair deforms more globally in the shape volume, rather than the individual hair strand. The self-intersection is not an obvious problem. It is not necessary to be represented geometrically and physically in line segments. Thus, a more specific way is possible besides directly applying a general method.

We have presented a strip-based framework that is suitable for real-time applications [4, 5]. The main idea is to model and animate hair in 2D strips. Each hair strip, modeled by one patch of parametric surfaces (NURBS in our implementation), represents a group of hair strands. A variety of shapes may be defined for each strip. For the rendering, we apply texture mapping with the alpha-channel on the tessellated polygons to achieve a realistic visual effect.

Continuing the real time hair animation and inspired the real time prairies animation [7], we propose a method of human short hair modeling and real time animation. A method is proposed to model the short hair. First, a hair style model is derived from a scalp model interactively. Then, the hair model is derived automatically from the hair style and scalp models. Texture mapping is applied to the hair model for a better visual effect. For animation, a method is proposed based on an approximation of the accurate physically-based hair model, from which the 3D morphing key shapes are derived. Then, the intermediate shapes are computed by applying 3D morphing. We have implemented it and compared the results with real hair. The visual quality and frame rate are satisfactory for real time applications[1] .

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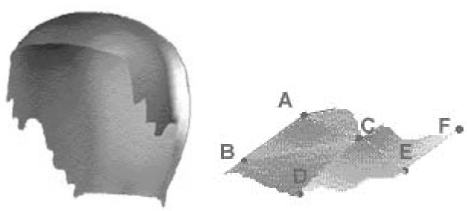
2. Modeling

In our method, the short human hair modeling involved of both interactive and automatic processes. Interactively, the user specifies the outline of the short hair style over a scalp model. A scalp model can be derived by using any other interactive modeling software or 3D digitizers. Based on the user defined outlines, 3D polygon meshes will be formed that define the areas where the hair pores are growing, i.e., a hair style model (Figure 1(a)).

Now, the hair model can be derived from the hair style model by an automatic process. An algorithm is developed for this purpose and summarized as follows:

First, the vertices of the hair style model are automatically retrieved, illustrated in Figure 1(b).



(a) (b)

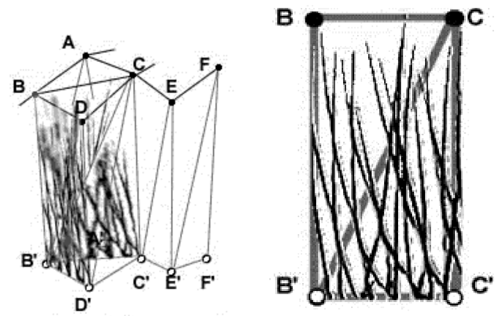
Figure 1. (a): An example a hair style model: a 3D polygon mesh that defines the area where the hair pores are growing. (b): A, B, C, D, E and F are vertices of a hair style model.

Second, a set of corresponding new vertices are created by adding an offset vector to the vertices of the hair style model.

The offset vector is derived for each vertex of the hair style model. It points inwards, i.e., the opposite growing direction of the hair at that vertex. The reason is that in the digitized hair scalp model, the polygon mesh usually represents the hair, not the skin. The magnitude of the offset vector represents the hair length, derived from scaling an average hair length randomly. The direction of the offset vector is decided according to its position and the hair style. Some patterns can be defined and used for both magnitude and direction for different variations of a hair style.

Third, the new triangle strips of hair model are created from connecting the scalp (hair style) and hair vertices vertically, as illustrated in Figure 2(a). Note that each new hair vertex corresponds to one old vertex in the scalp (hair style) model. They form a complete hair model.

Finally, in order to improve the visual effect, we apply the texture mapping with the alpha-channel on hair strips of the hair model, in a way similar to [4]. One example is shown in Figure 2(a) and 2(b) with some triangles of hair strip being texture mapped. Three examples of different short hair style are shown in Figure 3.



(a) (b)

Figure 2. New vertices A’, B’, C’, D’, E’ and F’ and triangles are crested from the old ones A, B, C, D, E, and F. Texture mapping is applied to the hair model.

3. Animation

Animation of the short hair is achieved by deforming the overall shape of the hair model. An approximation of physically-based method is proposed in order to achieve a real time result. In this method, the shape of hair model is deformed under force vectors. The resulting deformed shapes are used as the 3D morphing keys for generating the shapes of the intermediate frames. The purpose of 3D morphing is to accelerate the animation speed.

Without loss of generality, we describe our method with simulating the effect of the hair blown by a beam of wind generated from a hair dryer.

The approximation of an accurate physically- based hair model is shown in Figure 4(a). The approximation is based on the observation that short hair deforms more globally in the shape volume, rather than in that of the individual hair strand. In this mass-spring model, springs are used to link the vertices of the scalp model and the vertices of hair model. Mass is assigned to the vertices of the hair model mesh with external wind force represented by force vectors applying to them. The displacement of the affected vertices will be derived from applying Hooke’s law.

To accelerate the animation speed, for each force source, we define its influence range using a cone with the corner being the force source point and the direction of its axis being the same as the force vector. Only the hair vertices (mass points) inside the cone are affected (Figure 4(b)). This assumption is more suitable for short hair.

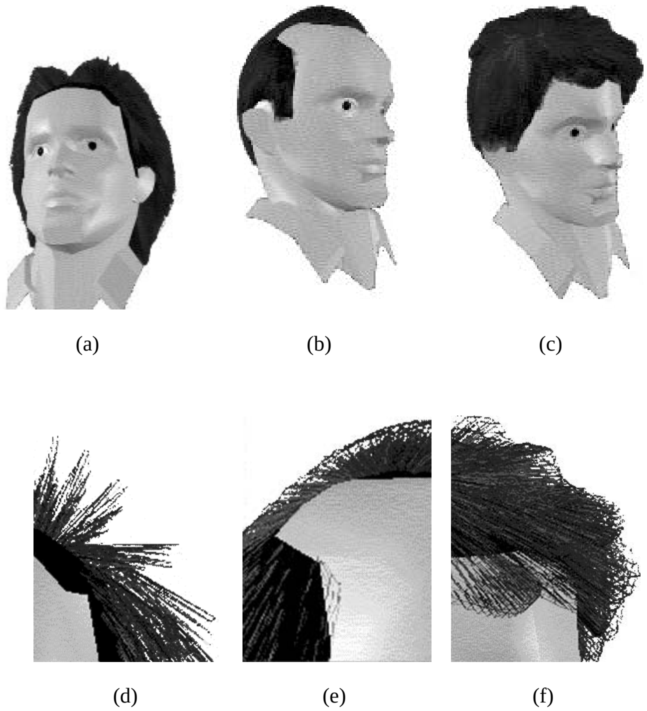


Figure 3. Rendering results of three hair models of different hair styles and the enlarged detail.

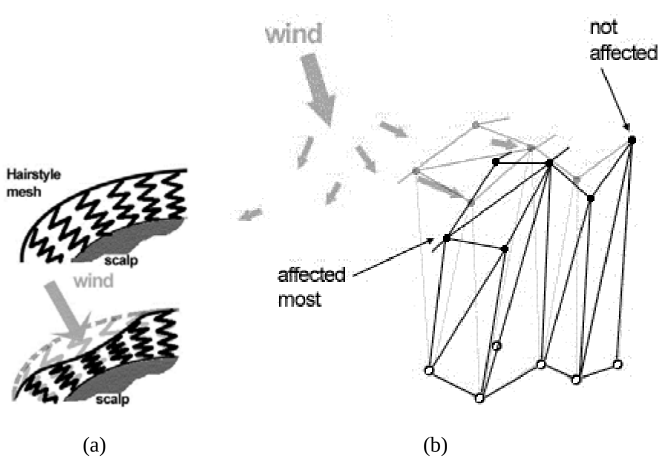


Figure 4. A mass-spring short hair model.

Furthermore, from computing using the mass-spring model, key shapes are derived and used as the 3D morphing keys. Then, the shapes of intermediate frames are computed using 3D morphing, a process faster than computing using the mass-spring model.

In Figures 5(a) and 5(b), we show two snapshots of the animation results, compared with two snapshots of real human short hair captured by digital video camera in Figures 5(c) and 5(d). The complete animation and captured real hair motion sequences can be found in http://www.comp.nus.edu.sg/ ˜huangzy/research.html. The results are satisfactory for real time applications. Two more snapshots of animating very short hair are shown in Figures 5(e) and 5(f).

4. Implementation

We have implemented it using Java 3D 1.2.1 and JDK 1.3.1. Figure 6 shows the Java 3D scene graph.

Note that the hairMorph object also has event handlers and morphing behaviors to control the actually morphing. By this way, the morphing keys can be interactively controlled by the user.

We tested our program on a Pentium 3 PC (1.0GHz, 512MB) with GeForce2 32MB card. The average frame rate is 18 fps for a hair model consisting of 17,388 triangles.

5. Conclusion

We have proposed a method of human short hair modeling and real time animation. In summary, our solution has the following advantages:

1. Ease of modeling: The system is able to model different hair styles, in an intuitive way.
2. Real time: The system applies simple dynamic model and 3D morphing to the hair model. The frame rate is 15 fps to 30 fps depending on the complexity of the model. It is suitable for real time applications.
3. Realism: The modeled human hair looks realistic. The animation of the hair is similar to the movement of real hair.

References

[1] K. Anjyo, Y. Usami, and T. Kurihura. A simple method for extracting the natural beauty of hair. In *SIGGRAPH 1992*, pages 111–120, July 1992.

[2] A. Daldegan, T. Kurihara, N. Magnenat-Thalmann, and D. Thalmann. Integrated system for modeling, animating and rendering hair. In *Eurographics 1993*, pages 211–221, September 1993.

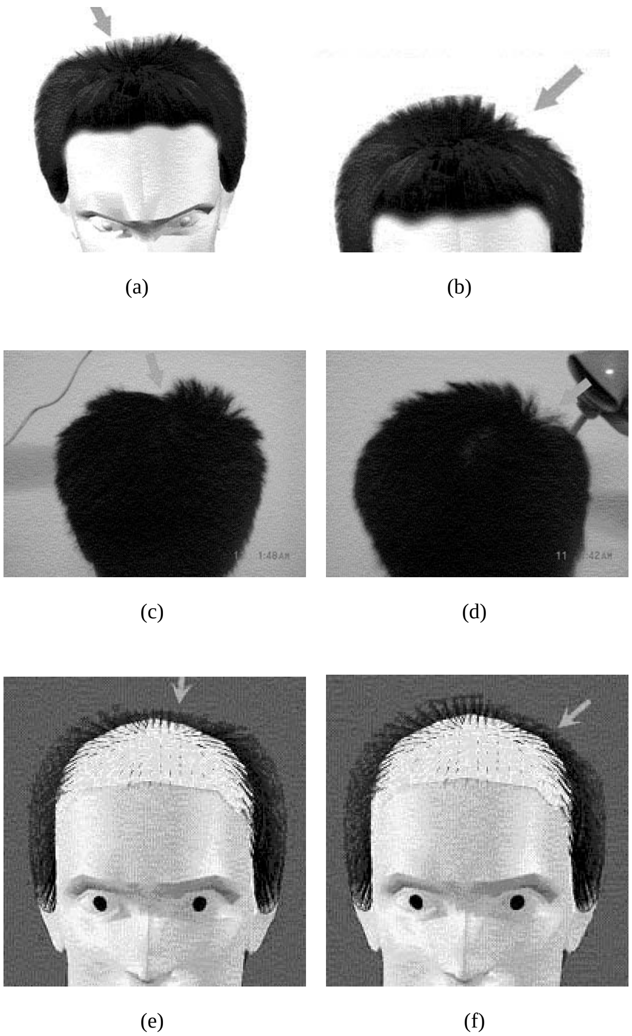


Figure 5. Animation result (a) and (b) comparing with the real hair (c) and (d). Two more results of animating very short hair are shown in (e) and (f) where the hair is deformed with a very small amount.

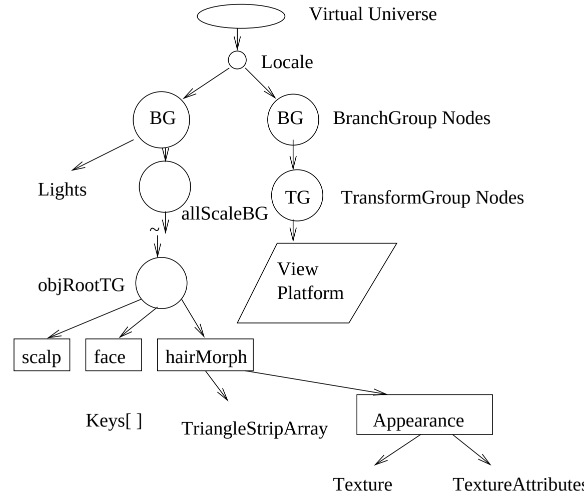


Figure 6. The Java3D scene graph in our implementation.

[3] S. Hadap and N. Magnenat-Thalmann. Modeling dynamic hair as a continuum. In *Eurographics 2001*, pages 329–338, September 2001.

[4] C. K. Koh and Z. Huang. Real-time animation of human hair modeled in strips. In *Eurographics Workshop of Computer Animation and Simulation 2000*, pages 101–110, September 2000.

[5] C. K. Koh and Z. Huang. A simple physics model to animate human hair modeled in 2d strips in real time. In *Eurographics Workshop of Computer Animation and Simulation 2001*, pages 127–138, September 2001.

[6] T. Kurihara, K. Anjyo, and D. Thalmann. Hair animation with collision detection. In *Models and Techniques in Computer Animation 1993*, pages 128–138, 1993.

[7] F. Perbet and M.-P. Cani. Animating prairies in real-time. In *ACM I3D 2001*, pages 103–110, March 2001.

[8] E. Plante, M.-P. Cani, and P. Poulin. A layered wisp model for simulating interactions inside long hair. In *Eurographics Workshop of Computer Animation and Simulation 200 2001*, pages 139–150, September 2001.

[9] J. C. Platt and A. H. Barr. Constraint methods for flexible models. In *SIGGRAPH 1988*, pages 279–288, July 1988.

[10] R. E. Rosenblum, W. E. Carlson, and I. E. Tripp. Simulating the structure and dynamics of human hair: Modeling, rendering and animation. *The Journal of Visualization and Computer Animation*, 2(4):141–148, 1991.

[11] D. Terzopoulos and K. Fleischer. Deformable models. *The Visual Computer*, 4(6):306–33, 1998.

[12] N. M. Thalmann and A. Daldegan. Creating virtual fur and hair styles for synthetic actors. In *Communicating with Virtual Worlds 1993*, pages 358–370, 1993.

[13] Y. Yu. Modeling realistic virtual hairstyles. In *Pacific Graphics 2001*, pages 295–304, October 2001.