Human Hair Drawing Based on Trigonal Prism and Wisp Model

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三角柱と房のモデルによる頭髪の生成

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1. Introduction

Human hair is a very complex object to draw it by CG technologies. Only a few reports have been published on human hair image generation[1][2][3]. This paper presents a new method of CG human hair generation using a trigonal prism model and a wisp model.

2. Hair Drawing

Yamana & Suenaga[1] applied an anisotropic reflection model to human hair generation, regarding hairs as a scratch-like texture on the human head surface. However, this method is time consuming, and the synthesized hair images had a somewhat "metallic" appearance.

In G.Miller's work[2], the anisotropic shading model was employed to produce furry images. He adopted the anisotropic shading on many hair "sticks" to get a more realistic image of the fur. His method is suitable for the generation of short, straight, thick (stick-like) hairs, shiny fur, hairy skins or needle leaves. Though he successfully obtained various furry images, his method is time consuming, too. Actually he spent 2.0 hours with the Celerity 1230[2].

Moreover, those methods were devised mainly for giving hair texture on some previously given surface. A CG hair model to design the hair style (outer shape) is needed. J.Weil[3] presented a technical slide and an animation video to SIGGRAPH'88. However, his algorithm has not yet been published, and the picture quality seems less than satisfactory.

3 Hair Model

Usually, there are 50,000 to 100,000 hairs in the hair area on the human head. Human hair appearance is characterized by the texture and outer shape of the hair(hair style). Both characteristics must be generated correctly from the CG hair model.

3.1 Representation of a hair (trigonal prism model)

Enormous number of patches is needed for the total hair set. If, for example, we suppose a hair is approximated by 32 cylinders and each cylinder is approximated by 32 triangular patches, and if a person has 100,000 hairs, the total number of triangular patches would become 102,400,000. It is impossible to draw such a big number of triangular patches in a reasonably short time.

In order to reduce the total number of patches, the authors employed a trigonal prism model shown in Figure 1. The bending of a hair is presented by connecting short trigonal prisms. A hair model is produced by controlling parameters on the length (l), angle (a, b and c) and thickness (d) of a trigonal prism. Various kinds of hair (straight, wavy or curly) are generated by controlling these parameters. Though trigonal prisms are a very bad approximation of cylinders, the appearance is drastically improved by employing smooth shading as shown in Figure 2.

3.2 Representation of hair bundle ("wisp" model)

The authors noticed that there are many bundles in a hair set. If the hair is combed, long bundles are formed in the hair. When hair is waving in the wind, the bundles appear as streams of hair. We make use of bundles, or "wisp" of hairs as units to efficiently draw the total hair set. By introducing wisps, the number of control parameters to obtain hair images is drastically reduced. Details of wisps are determined by the control parameters of each hair.

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Various hair images can be obtained by controlling only a small number of parameters, which are the number of wisps, the number of hairs in a wisp, hair length, thickness and color of each hair. By changing the number of hairs, hair thickness in a wisp is controlled. Hair style is determined by what shape of wisp is used and how many kinds of wisps are used. The idea of wisp based style control was introduced by analogy to hair cutting by hairdressers.

4. Experiments

The results of hair drawing on the human head are shown in Figures 4 and 5. Fig. 4 shows short curly hair. To obtain the effect of combing, Fig. 5 shows long hair made with hair wisps whose hairs are aligned in the same direction. It was necessary to control a lot of wisps and patches to complete Figs. 4 and 5. It takes only 10 minutes to draw total primitives using the IRIS-4D/70. Moreover, by removing "invisible" hair wisps on the rear side of head in advance, the rendering time has been reduced to only 3 minutes. Therefore, the processing is completed within a realistic turnaround time.

It has been proven that the proposed method is very effective for the generation of human hair images. By simply controlling the parameters, various styles and textures of hair can be generated by using standard graphics hardware.

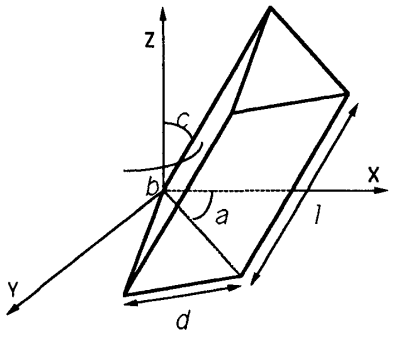

Fig. 1 Trigonal prism

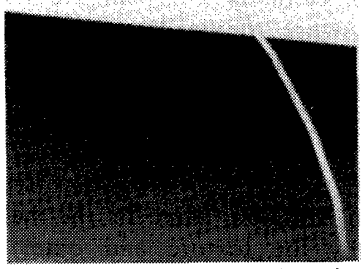

Fig. 2 a hair (prisms)

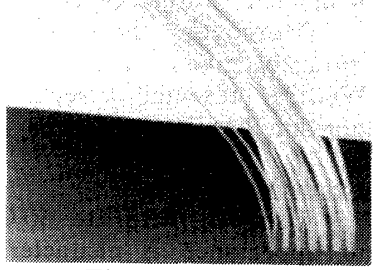

Fig. 3 Wisp

Fig. 4 Short curly hair

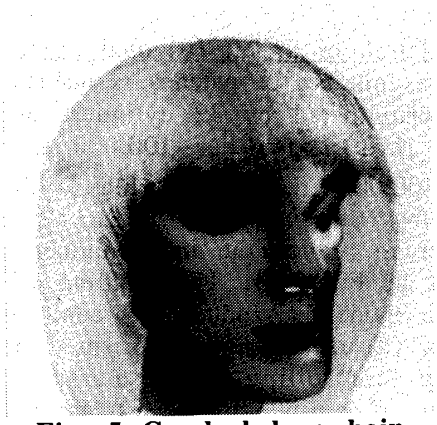

Fig. 5 Combed long hair

5. Conclusion

A practical method of hair drawing using only a small number of parameters was presented. Experiments using a typical CG workstation proved the proposed algorithm is very effective for the generation of various human hair images. A notable feature of the proposed method is that it is suited to the conventional z-buffer algorithm or hardware, which is known as the fastest practical rendering tool.

Reference

[1] T.Yamana and Y.Suenaga,"A Method of Hair Representation Using Anisotropic Reflection," IECEJ Tech. Report, PRU87—3, pp.15—20(May 1987)(in Japanese)
[2] G.S.Miller," FROM WIRE-FRAMES TO FURRY ANIMALS," Graphic Interface '88,pp.138—145
[3] J. Weil, Technical Slide and Technical Animation Video, SIGGRAPH'88