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# ＣＧ人物像の髪の生成手法

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0. Introduction:

Hair plays a very important role in human face image. However, it is still quite difficult and time-consumming to synthesis hair images. In this report, a new hair model "Plane-Wisp model" is proposed and explained.

1. Problems of previous approaches:

There are a few methods published to synthesis hair image and simulate hair's motion. We roughly divid them into two groups and explain their problems.

1.1 Explicit Models: The basic spirit of Explicit Models is to model each strand of hair as an individual object (for example, curved cylinder). This kind of approach is very intuitive and easy to apply some physics formulas to simulate the behavior of hair motion, although the maintenance of enormous amount of hair strand 3D information is very computationally expensive and comsumes memory extremely. Now let's consider figure1 . Because the width of one strand is so thin, there are usually more than 10 strands of hair being projected passing on one pixel. In other words , no matter how precisely the system maintains hair's 3D information , we still need to average the result to obtain an "estimated" pixel color in rendering stage. The above observation leads us to ask the following question : Is it really necessary keeping all the 3D information of each hair strand to generate hair image ?

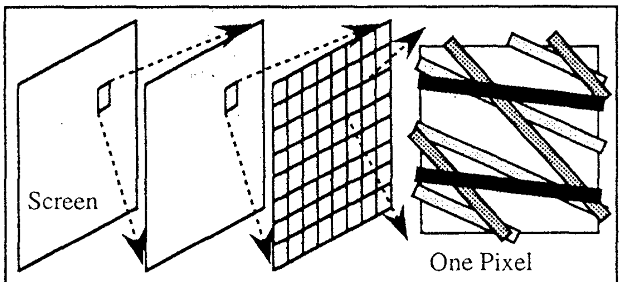

Fig 1. Pixel Coverage of Hair Strand

1.2 Volume Density Models: Volume Density Models achieve their visual effects by defining the texture function throughout a region in 3D space. For volume density model, animating the motion of hair needs to recompute the silhouette and the distribution of density in the 3D space. However, we must ask here: according what kind of physical models , can we do the above two tasks efficiently and satisfactorily?

2. A simple method for Rendering Hair:

We devide our method into two steps as shown in Figure 2.

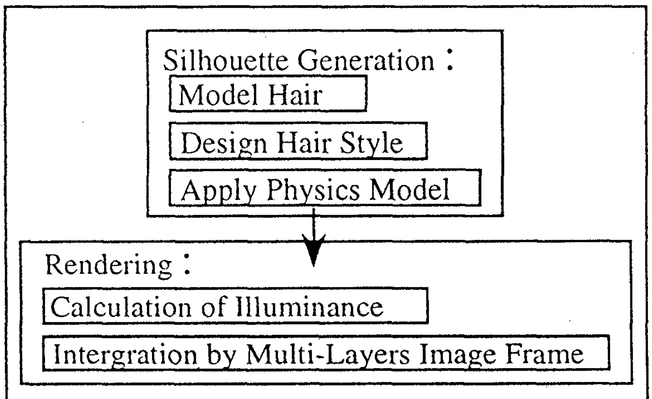

Fig 2. The procedure of hair image synthesis

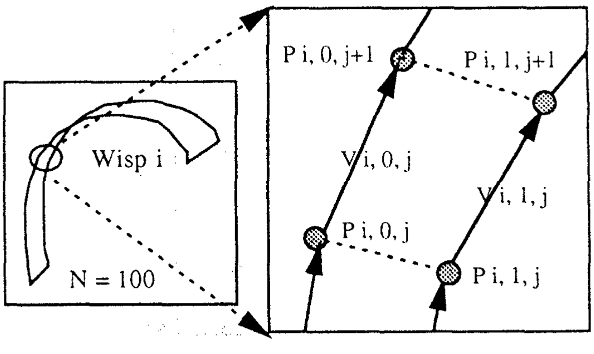

Fig 3. Wisp Model

2.1 Generating the Silhouette of Hair:

The first step is the generation of the silhouette (or outlines) of the region of hair in 3D space. We define our hair model as a set of plane-wisps because the strands of hair within it are locally parllel.

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A Simple Method for Human Hair Generation Using the Plane-Wisp Model
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Each plane-wisp consists of several small plane patches and two "control hair strands" (Fig 3). The control hair strands are composed of several short line segments. We also assign a value to each wisp seperately to indicate how many strands of hair it has to control the thickness of wisp. This model is very intuitive and easy for us to apply some physics law to calculate hair position.

2.2 Rendering the texture of hair: Now, we have the 3-D discriptions of the outlines of wisps as the result of step1. For each plane patch, we first project it onto display plane (Fig 4a). Then we "find" the pixels on the edges Ei,j from P wisp i,0,j to P wisp i,1,j and Ei,j+1 from P wisp i,0,j+1 to P wisp i,1,j+1. According to N ( the number of strands ) which is assigned to Wisp i, we can assign values to each pixels on edges Ei,j and Ei,j+1 to indicate the numbers of strands being projected on the pixel (Fig 4b). Now, we can determine the number of hair strands to all the pixels on the plane (Fig 4c). Here we assume the distribution of hair strands within one wisp is uniform. In fact, we can obtain different type of wisps by varying hair disstribution on it.

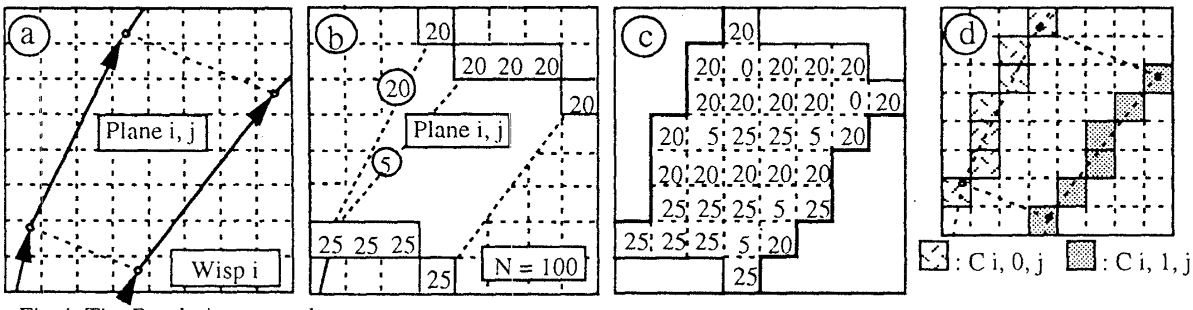

Fig 4 The Rendering procedure

We use the 3D information within the control strand to "color" the pixels on the boundary edges of each plane patch (Fig 4d). The illuminance density is calculated through the following formula: $C = LaKa + \Sigma Li [ Kd \sin\theta + Ks \cos^{n}(\phi + \theta - \pi )]$. We "color" other pixels between the edges by interpolation. Then we can combine these values with the distribution of hair to calculate the illuminance density of the pixels on the plane.

In the final stage of rendering, we integrate all plane patches to obtain the whole image of hair. Here, some efforts are devoted to simulate the translucent property of hair. The idea is enlightened from one of the watercolor artists' techniques. When watercolor artists create voluminous feeling and translucent visual effects, they repeat painting color layer on layer to obtain the desirable visual effect. In our case, we use three layers of image frames to implement this idea (Fig 5). We assume that only the first 16 hair strands nearest eyes are " visiable ". According to this assumption , when there are already 16 or more than 16 strands being projected on one pixel, we shoud not be able to see anything behind it . Otherwise, this pixel is still translucent. The color behind it can still contribute to the illumination of this pixel.The illuminance density of pixels are blended under this strategy.

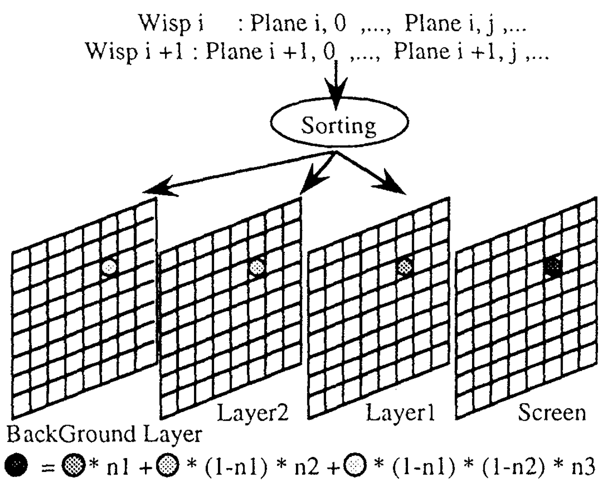

Fig 5. Multi-image-frame architecture

3. Conclusion :

We have proposed a new model and developed a simpler method to synthesis hair image. We are now performing the experiment and evaluation of this method.

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