Assignment 2: Simulation of hair motion with moving head

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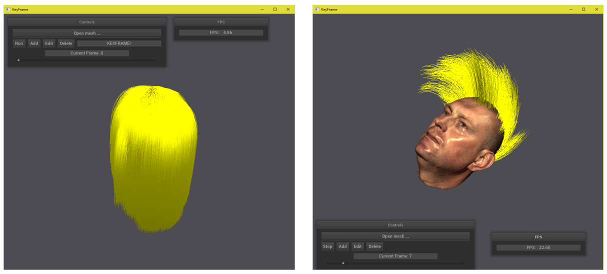

(a) Resting hair. (b) Hair in motion.

Fig. 1. Examples of resting hair and hair in motion. Notice the shading change in (a) caused by hair collision with ear.

Fig. 2. Head model with hair part labeled with black.

1 INTRODUCTION

In this assignment, the goal is to implement hair motion simulation with a moving head. My implementation is based the key frame animator in assignment 1. The key functions are listed below.

- Generate hair guide strands on the human head.
- Handle Head-hair collision using mesh collider.
- Use Kajia-kay for hair rendering.

2 IMPLEMENTATION DETAILS

2.1 Hair Generation

Initialization. I painted the scalp area in black color using Blender[1], the result is shown in Fig2. After loading the colored model, I am able to get a label for each vertex. The label is 1 if the vertex belongs to scalp, otherwise the label will be 0. When generating hair, the root position will be uniformly sampled from vertices with label 1. The initial normal of the hair strand is the vertex normal of model.

Interpolation. For hair interpolation, I used the Archimedean spiral algorithm. Given the normal n a hair point position, first compute the local tangent vectors u, v. u,v and n are the local coordinate and are orthogonal to each other. The offset factor on u and v are computed with the following function,

$$x = (a + b\theta)\cos\theta \tag{1}$$

$$y = (a + b\theta)\sin\theta \tag{2}$$

where θ is the rotation angle, a specifies how to turn the spiral, while b controls the distance between successive turnings. a and b are both set to 2 in my implementation.

Tessellation. Hair strands are smoothed using Bazier Curve. As shown in Fig.1(b), there are 10 segments on each hair strand. Instead of directly drawing the line strips connecting each point, I use Bazier curve to make the result smoother.

2.2 Simulation

The simulation is implemented using basic mass-spring model. The stiffness force and damping force are computed using the following equations.

$$F_s = k_s(l - l_0), \tag{3}$$

$$F_d = k_d v, \tag{4}$$

where F_s and F_d stands for stiffness force and damping force. l is the current spring length and l_0 is the rest length. v is spring velocity.I also use length constraint in my simulation. The length l is not allowed to extend or curtail more than 10% of the resting length.

2.3 Collision Detection

In order to get more precise collision results, I use mesh collider for this assignment. To speed up the process, I created a BVH tree for the head model, When a hair segment penetrates head, I will add an extra force starting from the center of the head to the collision point.

2.4 Rendering

Finally, the hairs are rendered with Kajiya-Kay shading[2], the results are shown in Fig.1.

REFERENCES

[1] T. B. I. houses the Blender Foundation, “Blender,” https://www.blender.org/.
[2] J. T. Kajiya and T. L. Kay, “Rendering fur with three dimensional textures,” in *ACM Siggraph Computer Graphics*, vol. 23, no. 3. ACM, 1989, pp. 271–280.