Assignment 3: Simulation of Hair Motion with Air Interaction

NAME: LI YUWEI
STUDENT NUMBER: 45895086
EMAIL: LIYW@SHANGHAITECH.EDU.CN

1 INTRODUCTION

In this assignment, the goal is to implement hair motion with air interaction. My implementation is based on the hair simulation method in assignment 2. The key functions are listed below.

- Add air flow in the simulation scenario to make hair flutter.
- A coupling of air motion and hair.

2 IMPLEMENTATION DETAILS

2.1 Air simulation

Given the famous imncompressible Navier-Stokes equations, I use the method in [1] and distretize the space using MAC grid.

According to the following functions:

$$\frac{\partial \vec{u}}{\partial t} = F \tag{1}$$

$$\frac{\partial \vec{u}}{\partial t} + \vec{u} \cdot \nabla \vec{u} = 0 \tag{2}$$

$$\frac{\partial \vec{u}}{\partial t} - v\nabla \cdot \nabla \vec{u} = 0 \tag{3}$$

$$\frac{\partial \vec{u}}{\partial t} + \frac{1}{\rho}\nabla p = 0 \; such \; that \; \nabla \cdot \vec{u} = 0 \tag{4}$$

I update the velocity field with four steps, add force, diffusion, advection and projection. For the interpolation in advection step, I use trilinear interpolation. Diffusion and projection are solved using Jacob method. For grids located at boundaries, I set the velocities to zero as a boundary condition.

2.2 Coupling Air Flow with Hair

For each segment on a hair strand, I find the corresponding velocity in the fluid field using trilinear interpolation. When air flow hits hair, the velocity of air flow at the object surface should be the same (zero relative velocity). Given the fluid velocity v_f and hair velocity v_h, I add v_f to hair as an extra force. After looping through all hair segments, I achieve a new velocity at each hair segment. Then fluid velocity field is updated according to these sub-grid velocities. For each grid center, the velocity increment is the weighted sum of nearby velocities using a Gaussian kernel shown as follows,

$$w(d) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2}(\frac{d-\mu}{\delta})^2} \tag{5}$$

where d is the Euclidean distance between hair point to grid center.

3 RESULT

3.1 Velocity field

As Figure2 shows, this is the velocity change with x-axis force.

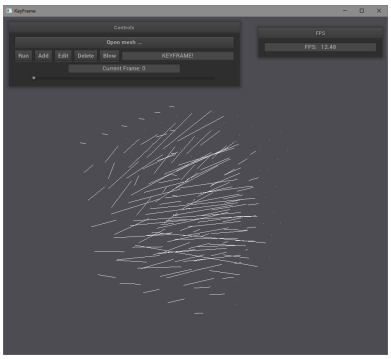

Fig. 1. A visualization of the velocity field. Grid size is $6 \times 6 \times 6$.

3.2 Coupling

The following figure shows the hair motion at velocity field in Figure.2.

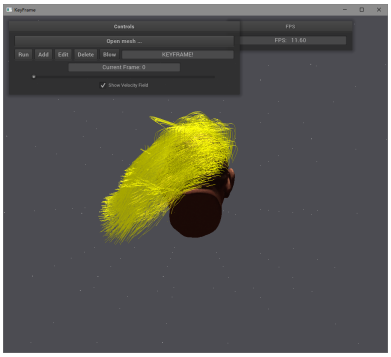

Fig. 2. Hair motion with air flow.

REFERENCES

[1] J. Stam, "Real-time fluid dynamics for games," in *Proceedings of the game developer conference*, vol. 18, 2003, p. 25.

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