Assignment 5: Animation with Cloth Simulation

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1 INTRODUCTION

In this assignment, the following tasks are finished with the most simplest cloth simulation based on mass spring system to do a physically based animation by using OpenGL.

- Task1: Force computation with Hooke's law
- Task2: Structural, shear, and bending springs
- Task3: Fix the location of two mesh points to stop the cloth falling down
- Task4: Real-time and stable animation
- Bonus1: Apply external forces to the cloth to simulate the behavior of wind
- Bonus2: simulate a piece of cloth falling on a sphere
- Bonus3: Drag a mesh point to move the cloth with mouse in real-time

2 IMPLEMENTATION DETAILS

Briefly introduct tcloth simulation based on mass spring system.
initially, there exist a rectangle symbolized a cloth. The cloth a devided into 40×30 mashes.
Some mashes can been seen as connected by a spring, with the usage of spring's Hooke's law, and the gravity, we can compute each mesh's force, acceleration, velocity, then we can simulation how the cloth is going to move.

2.1 Force computation with Hooke's law

we regard the cloth's mass is mass_weight(2kg), and the cloth are devided into 40×30 mass points, so each mass point has the mass of $\frac{2}{30 \times 40}$.
according to Hooke's law $F = k\Delta x$
suppose the two connected mash points are at the location $\mathbf{p}, \mathbf{q}$
so the force on $\mathbf{p}$ is $\mathbf{F} = k \cdot (L_0 - ||\mathbf{p} - \mathbf{q}||) \frac{\mathbf{p}-\mathbf{q}}{||\mathbf{p}-\mathbf{q}||}$, where L_0 is the initial length of the spring.

2.2 Structural, shear, and bending springs

the mass points are connected by massless springs.
for a mass point (i, j), there exist three kinds of springs.

- structural sptring.
  connected $(i, j) - (i + 1, j)$ and $(i, j) - (i, j + 1)$
- shear spring connected $(i, j)-(i+1, j+1)$ and $(i+1, j)-(i, j+1)$
- flexion spring connected $(i, j) - (i+2, j)$ and $(i, j) - (i, j+2)$

2.3 Fix the location of two mesh points to stop the cloth falling down

The two mesh points at the left-top and right-top corner of the cloth are considered as fiexed.
So no matter how other mash points affected it, the acceleration and the velocity never changed, and its position never changed to make it being fixed.

2.4 Real-time and stable animation

We need to calculate the force that the mass point forced. The forces are the spring's force, the gravity's force, and a dampling force to make it stop moving.
the spring force are said above, the gravity for $G = -mg, g = (0, 9.8, 0)$, and the dampling force $F = dampling\_ratio \cdot \mathbf{q}_{i,j}$, where $v_{i,j}$ is the velocity vector of point $P_{i,j}$.

And for every time changes
$Deltat$, we can calculate that
$\mathbf{a}_{i,j}(t + \Delta t) = \frac{\mathbf{F}_{i,j}(t)}{m}$
$\mathbf{v}_{i,j}(t + \Delta t) = \mathbf{v}_{i,j}(t) + \Delta_t \cdot \mathbf{a}_{i,j}(t + \Delta t)$
$\mathbf{P}_{i,j}(t + \Delta t) = \mathbf{P}_{i,j}(t) + \Delta_t \cdot \mathbf{v}_{i,j}(t + \Delta t)$

2.5 Apply external forces to the cloth to simulate the behavior of wind

We can add transverse wind to make the clothes has the effect of blowing.
We can use a Gaussian function to make the wind better to be seen. let the wind cycle from left to right, the center of the wind is regarded as the strongest.

2.6 simulate a piece of cloth falling on a sphere

We can move the sphere on the path where the cloth falls.
The radius of the sphere is 0.5// When one of the mass point of the cloth has a collision with the sphere, we need to move mass out of the ball slightly along the normal vector.
And set the velocity along the normal vector of the ball at the collision point into 0.

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2.7 Drag a mesh point to move the cloth with mouse in real-time

first, we need to change the mouse's coordinate from the screen space to the world space with a sieze of transformations.
Then, we need to judge whether the mouse and one of the mass point are in the same line with the camera, if so, we can regard that the mass point can be selected by the mouse.
then we can regard that mass point is a fixed point, and it is moving with the mouse in real time.

3 RESULTS

the results can be seen in the pictures.

- Fig. 1. The normal model after falling off.
- Fig. 2. With the transverse wind based on the Gaussian function.
- Fig. 3. The cloth is having a collision with the sphere.
- Fig. 4. One of the mass is fixed with the mouse moving.

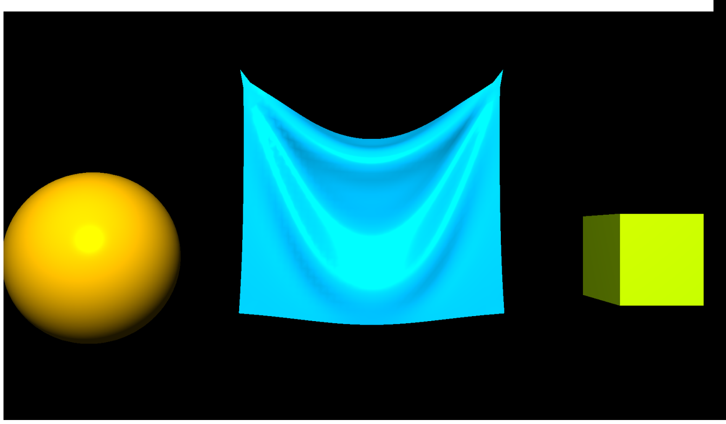

Fig. 1. the falling down model

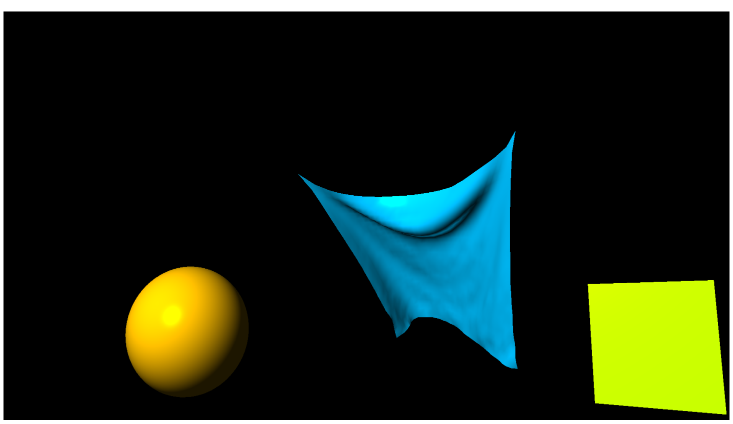

Fig. 2. with the behavior of wind

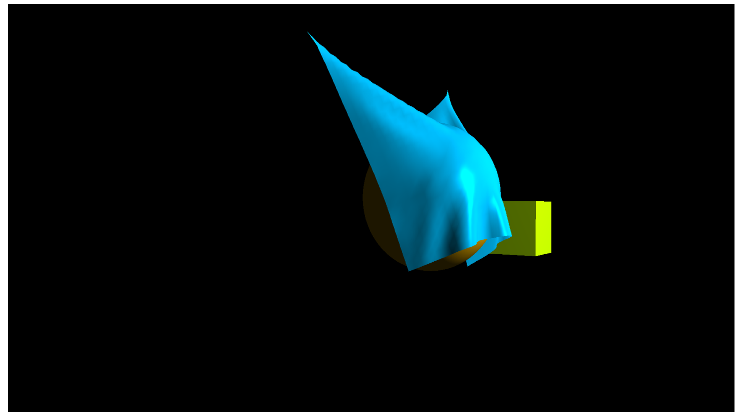

Fig. 3. collision with sphere

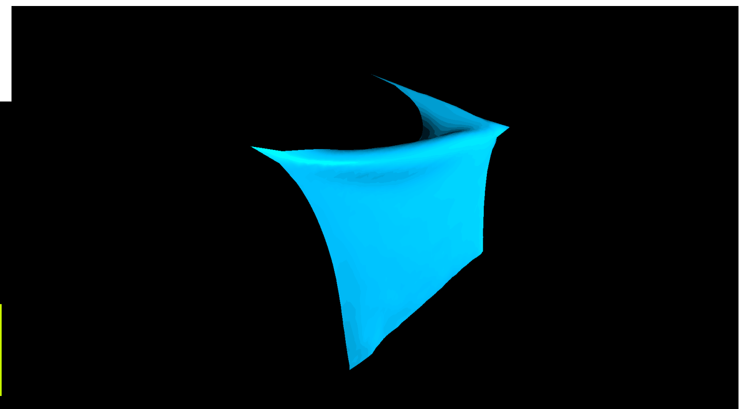

Fig. 4. mouse control