Assignment 5: Rigid Body Simulation

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1 INTRODUCTION

- Synchronize the simulation and the rendering in OpenGL to show the result in real time.
- Implement the collision detection between the parallelograms and the sphere.
- Implement the collision adjustment so that the inter-penetration is within the given tolerance (a small threshold).
- Implement the colliding contact handling between the the parallelogram and the sphere without consideration of rotation.
- Simulate with multiple spheres simultaneously.

2 IMPLEMENTATION DETAILS

2.1 movement by time

$$a = \frac{F}{m}$$

$$v_{t+\Delta t} = v_t + \Delta t \cdot a$$

So , we can get the new velocity by adding the acceleration to the old velocity. And get acceleration by the force.

2.2 collision detection

2.2.1 parallelogram and sphere. Firstly, we need to calculate the distance between the sphere and the parallelogram, and determine whether the distance is shorter than the radius of the sphere which means there may be a collision. Secondly, if shorter, we need to know whether the collision point of the sphere and the surface of the parallelogram is inside the parallelogram. By judging whether the point is inside the rightangle of the $\mathbf{P_0P_1}, \mathbf{P_0P_3}$, and $\mathbf{P_2P_1}, \mathbf{P_2P_3}$ separately, we can easily tell if the collision point is inside the parallelogram.

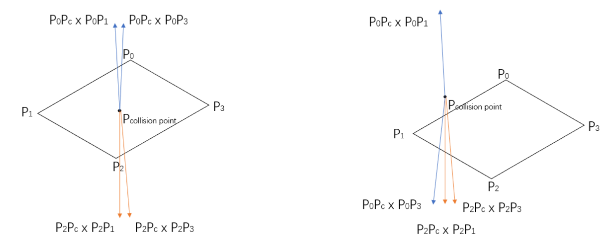
2.2.2 sphere and sphere.

2.3 collision adjustment

This is much easier to implement than the previous one. Just like the previous one, we need to calculate the distance between the two spheres, and determine whether the distance is shorter than the radius of the sphere which means there may be a collision.

2.4 collision handling

Computer Graphics I Course Assignment



(a) collision point is inside the parallelogram (b) collision point is inside the parallelogram

Fig. 1. whether inside the parallelogram

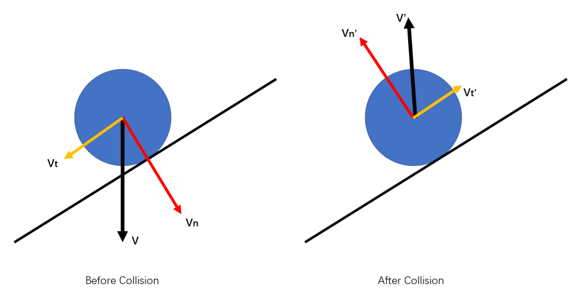


Fig. 2. shpere and parallelogram collision

2.4.1 parallelogram and sphere. Seeing that the wall is unmovable, so the collision only changes the sphere's **speed**. By the define of elastic Collision:

$$||V'|| = e \cdot ||V||$$

where e is coefficient of restitution, and we have given the coefficient of restitution on the normal direction and the tangential direction. We just separate the incoming V and reverse the them and multiply the coefficient of restitution.

2.4.2 sphere and sphere. Initial momentum conservation equation:

$$e \cdot m_1 v_1 + m_2 v_2 = m_1 v_1^{'} + m_2 v_2^{'}$$

Conservation of kinetic energy equation:

$$e^2 \cdot (\frac{1}{2} m_1 v_1^2 + \frac{1}{2} m_2 v_2^2) = \frac{1}{2} m_1 v_1^{'2} + \frac{1}{2} m_2 v_2^{'2}$$

We will get the new velocity of each object after substitute into the equation.

$$v_1^{'} = \frac{(m_1 - m_2)v_1 + (1+e)m_2 v_2}{m_1 + m_2} v_2^{'} = \frac{(m_2 - m_1)v_2 + (1+e)m_1 v_1}{m_1 + m_2}$$

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3 RESULTS

mp4 files in the report dir.