CA Homework1 　0416206 李明峻

1. Introduction/Motivation :

   The basket net is built in 3 dimensional space based on mass-spring system、gravity and friction world，we have to handle spring force and damper force of all the springs of the net，and to calculate position、velocity and force of each particles of the net. On the other hand，when throwing the balls to our scene，we have to control the collision of each stuffs，for example : net particles collide balls、net particles collide floor plane、balls collide floor plane or balls collide balls，we also have to consider the frictional effect when collision occur，combining all the conditions mentioned above，we can finish this homework.

2. Fundamentals :

   First part is connect all the particles by springs，and set some spring parameters and coefficients.

   Second part is compute Spring force and Damper force，after computing them，add two force to each particle.

   Third part is handle collision.

   Last part is integrate all the movable particles' moving track by Explicit Euler method，another method is Runge Kutta 4^{th}.

3. Implementation :

   First part :

`InitializeSpring()` in GoalNetModel.cpp :

Checking each particles by its neighbors from three direction，and connect them by the initialized spring.

Second part :

`ComputeSpringForce()` and `ComputeDamperForce()` in GoalNetModel.cpp :

According to the formula of spring force :

$$= -k_s(|\vec{x}_a - \vec{x}_b| - r)\frac{\vec{x}_a - \vec{x}_b}{|\vec{x}_a - \vec{x}_b|}$$

According to the formula of damper force :

$$= -k_d \frac{(\vec{v}_a - \vec{v}_b)\cdot(\vec{x}_a - \vec{x}_b)}{|\vec{x}_a - \vec{x}_b|}\frac{(\vec{x}_a - \vec{x}_b)}{|\vec{x}_a - \vec{x}_b|}$$

Then combine two force in `ComputeInternalForce()` .

Third part :

`NetPlaneCollision()`

`BallPlaneCollision()`

`BallNetCollision()`

`BallToBallCollision()`

Four functions in CMassSpringSystem.cpp :

Considering the net particles collide floor plane first，I create the plane by myself by adding an origin point and an orthogonal vector N，then check collision by $\mathbf{N}\cdot(\mathbf{x}-\mathbf{p})<\varepsilon$ and $\mathbf{N}\cdot\mathbf{v}<0$，for 'N' is orthogonal vector N of the plane and 'x' is the position of the particle and 'p' is origin point of the plane. Next，we check whether the particle is heading the plane or not by $\mathbf{N}\cdot\mathbf{f}<0$ which 'f' is the force direction vector of the particle，if so，do $\mathbf{f}^c=-(\mathbf{N}\cdot\mathbf{f})\,\mathbf{N}$ which 'fc' is the additional force，and $\mathbf{f}^f=-k_f(-\mathbf{N}\cdot\mathbf{f})\,v_t$ which 'ff' is the friction force，add two force to the particle，and set new velocity of the particles at last. Then we use the same conception to compute Balls collide plane.

Secondly，we use $v_1'=\frac{v_{1n}(m_1-m_2)+2m_2v_{2n}}{m_1+m_2}+v_{1t}$ and $v_2'=\frac{v_{2n}(m_2-m_1)+2m_1v_{1n}}{m_1+m_2}+v_{2t}$ to compute the velocities of two collided balls. Then also use the same conception to solve balls collide Net particles problems.

At last，we use Explicit Euler method and Runge Kutta 4th method，in Explicit Euler method，I set velocity first，then set new position；in Runge Kutta 4th method，calculating K1 ~ K4 delta position and delta velocity for each particle，and get average slope and velocity，updating them by reset the position and velocity.

4. Result and Discussion :

the difference between Explicit Euler and RK4 :

we will get more and more deviation during computing the track by Euler method，so using RK4 would be more precise，because this method will redirect the direction of the track many times by computing the position and instantaneous speed at half of delta time，which makes the track more real.

Another difference is that in Euler method the time step can't be so high，or the system would be disordered，but in RK4，the time step tolerance is higher than Euler method.

effect of parameters :

Spring coefficient :

high spring coefficient represent tight spring；low spring coefficient represent loose spring.

Damper coefficient :

High damper coefficient represents the springs recover to rest state more fast；low damper coefficient represents the springs maintain stimulated state for long period.

5. Conclusion :

   Through this homework，I found that I learned more knowledges about the mass-spring system and collision effects，sort of interesting when you completely understand the principles of each physical equations and theorems，then transform them to code and implement the result，it’s very fulfilled.