COMPUTATIONAL GRAPHICS FINAL PROJECT: CLOTH SIMULATION ON OPENGL

INSTITUTO TECNOLÓGICO DE ESTUDIOS SUPERIORES DE MONTERREY CAMPUS SANTA FE

Authors
Abraham Esses
Pablo de la Mora

Abstract

Based on a computational graphics course, we made an OpenGL project that makes use of Bezier surfaces technique, we used a model of an activity to dress her up with a skirt, which is responsive to leg movements.

We used Verlet Integration for the movements of the skirt, so it can be based on particles and physics.

Regarding the activity, it covered to make a character which should have movements on every articulation, simulating a human body and its body parts.

Movements were based on combination keys, and is builded with solid-type shapes, where we managed to shape a body with 3D spheres, varying its volume and size.

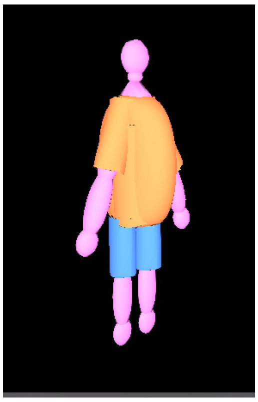
On each shape we have assigned a material with glMaterialfv function, so it can be colored.

Introduction

This project is a deliverable of our Computational Graphics course, where we proposed to make a clothes simulation behaviour based on human parts movements. So we firstly based on a activity we made on the class that consisted on building a 3D human body with OpenGL library, simulating all body articulations movements based on rotation, translation and torque on head, neck, spine, arms, forearms, shoulders, wrists, legs, knees, ankles, feet.

On every body part, was considered every possible real movement, and also limited to an amount of degrees to be moved. The body was built with 3D shapes provided by GLUT library, on our case, we chose to use spheres as any part of the body, just varying the radius and height of a sphere, simulating the body parts.

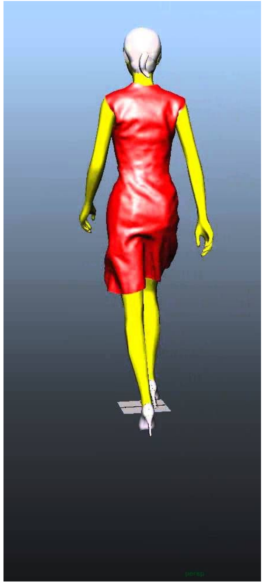
For example, head was modeled as a single normal sphere, but neck was a contracted sphere on Y axis, so it will be more slim than a normal sphere.



Picture 1. First phase, when stickman is dressed.

Then based on this project we have added some Bezier surfaces, to simulate that the body is dressed and so next step to be just altering the shape of the surface, making peaks and off-peaks, based on the move that is done by the stickman.

The desirable result (See Picture 2) is to have a full body with cloth simulation, but as far for time consumption, we wouldn't be able to end it on time on due date, so we then decided to cut the instalment to a woman's body and simulate her skirt movements with help of some formulas and techniques which are used on the industry.

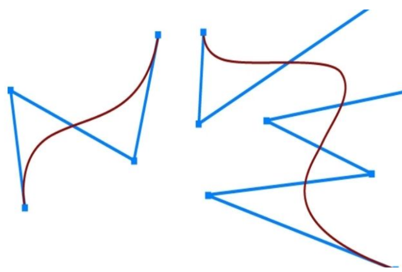


Picture 2. Desirable simulation of a dress on a woman's body.

<u>Mathematical Background</u>

Bezier
It has a particularity, which is, that always has an initial and a final control point, also the curve shape follows a polygon shaped with control points.

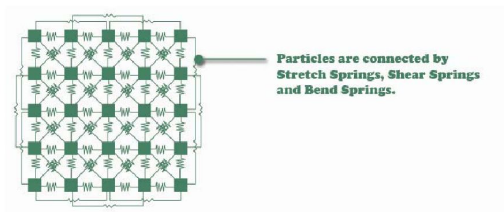
A surface is created with a bunch of little polygons, similar to an integral, which looks to get an approximate of an area, this technique, looks to have a surface having a lot of little polygons shaping it as patches.



Picture 3. Bezier curves.

Mass-Spring-Damper Model

Consists on modeling a grid of particles that are united with springs, they have a coefficient of damping, that are affected by forces, the particles have a displacement on in every time space (t)



Picture 4. Mass-Spring-Damper Model

Gravity: gravity is simply a force porportional to the mass of the particle. We can use the equation:

$$f_g = mg$$

Spring-Dampers: A spring-damper is defined by three constants: its spring constant K_s, a damping factor K_d, and its rest length l_0. We can compute the force using the equation:

$$\begin{aligned} f_1 &= -\left[k_s(|p_1 - p_2| - l_0) + k_d\left(\frac{(v_1 - v_2)\cdot(p_1 - p_2)}{|p_1 - p_2|}\right)\right] \cdot \frac{(p_1 - p_2)}{|p_1 - p_2|} \\ f_2 &= -f_1 \end{aligned}$$

Formula 1. Force calculation formula.

<u>Verlet Integration</u>
Is very often used on trajectories of particles on molecular dynamics.

So we did use it to calculate delta position on a very little moment (t), which calculates the next position of the particle.

- set $\vec{x}_1 = \vec{x}_0 + \vec{v}_0\,\Delta t + \frac{1}{2}A(\vec{x}_0)\,\Delta t^2$
- for *n=1,2,...* iterate

$$\vec{x}_{n+1} = 2\vec{x}_n - \vec{x}_{n-1} + A(\vec{x}_n)\,\Delta t^2.$$

Formula 2. Verlet Integration formulas for Delta.

It takes into account a velocity which we set to a constant 0.1f, so it will not affect more the movement.

As for the forces interacting into the skirt, is the gravity, the damping force of the springs dumping, and wind direction and force.

For collisions, we have set some spheres that will collide to the skirt particles, so then the contact point between them can be calculated in a manner that can be seen clearly and without affecting other body parts.

The refresh time is every 25 ms.

Results

Firstly, we encounter some problems calculating the amount of force that was acting into the grid of particles, actually if is moved out of limit the leg, the skirt disappears, so we have fixed more the limit to the leg movement.

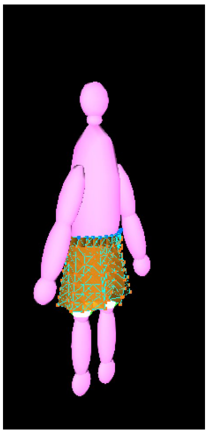
Then as we mentioned, set a some spheres on knees and hip, that helped us to make the movement more natural, and to have a contact point which will make calculations more efficient.

As far of the project, we got very good results of the representation of the collisions between the leg and the skirt.

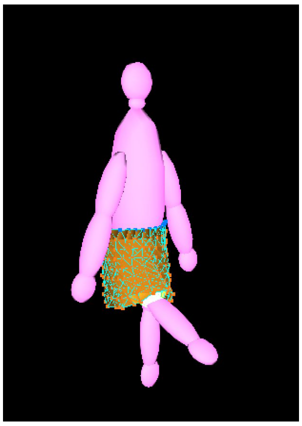
With keys combinations we make body parts move, for project purpose we move with "g" forward left leg and with "G" is moved backwards.

Same with "j" key and "J", for the right leg.

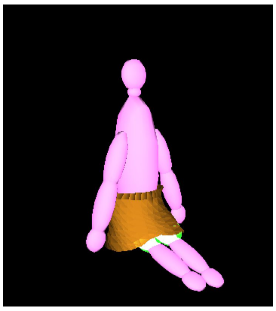
To change wind direction "5" and "6" and to change wind force "3" and "4"

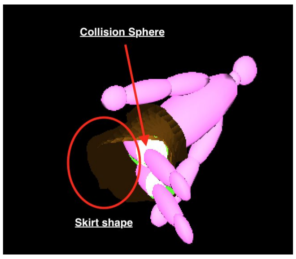


Picture 5. Skirt model on repose.



Picture 6. Skirt reacting to collision.





Picture 7. Skirt without debug, reacting to both legs.

Conclusions

We have learned quite a lot of how much work is to have graphics work the way is intended, and er could imagine, how much work could take to really get a videogame from this low grade.

It is a relief that there are a lot of engines and applications that simplifies calculations and generation of many computational graphics to developers.

This project also helped us to understand a little bit more of physics and math that is applied to graphics.

We would have liked to have more time to develop better features to this character so we can really get to desirable target.

References

http://graphics.cs.cmu.edu/nsp/course/15-464/Spring11/afs/asst3%20handout/15464-Assignment3.pdf

https://www.saylor.org/site/wp-content/uploads/2011/06/MA221-6.1.pdf