Prog3 Technical Writeup

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The Problem

The task is to create physically based animation for a swinging hula skirt. The skirt is to be modeled as a triangular mesh cylinder which is textured to look like a hula skirt. Each edge (including the top-left to bottom-right diagonals) acts as a spring force on its vertices. Thus each vertex is acted on by six spring forces (above, below, left, right, upper diagonal, and lower diagonal). The vertices are also affected by gravity. The last force affecting the mesh is provided by an oscillatory motion enacted on the top row of vertices. This force only indirectly affects subsequent rows of vertices via the springs. The springs become looser near the bottom of the skirt while the springs near the top are stiffer.

Approach

I achieved all of the requirements of this project. The skirt is modeled as a triangle mesh cylinder which is textured as a hula skirt. Each edge acts as a spring force on its vertices. Note: I chose to use top-left to bottom-right diagonal edges. Each vertex is affected by its six neighboring spring forces, by gravity, and by spring damping. The only row directly affected by the oscillatory motion is the top row of free-motion vertices; all subsequent rows' vertices are affected indirectly by their spring forces.

The user can adjust the motion of the skirt by increasing or decreasing both the amplitude and frequency of the oscillatory motion. They may also switch between a 2D swing about the z-axis or a 3D swing about both the x-axis and z-axis, independently.

The vertex positions are determined using a system of force equations (one for each spring force, one for gravity, one for the oscillatory motion, and one for spring damping) which are applied as acceleration. The velocity of a given vertex is determined via Euler integration of acceleration in which all of the accelerations are summed up. The position of a given vertex is also determined via Euler integration of velocity in which all the velocities are summed up. Note: I used Hooke's Law to simulate the springs at each edge. Also, the spring constant, Ks, decreased row by row toward the bottom of the skirt thus making the skirt looser near the bottom and stiffer near the top.

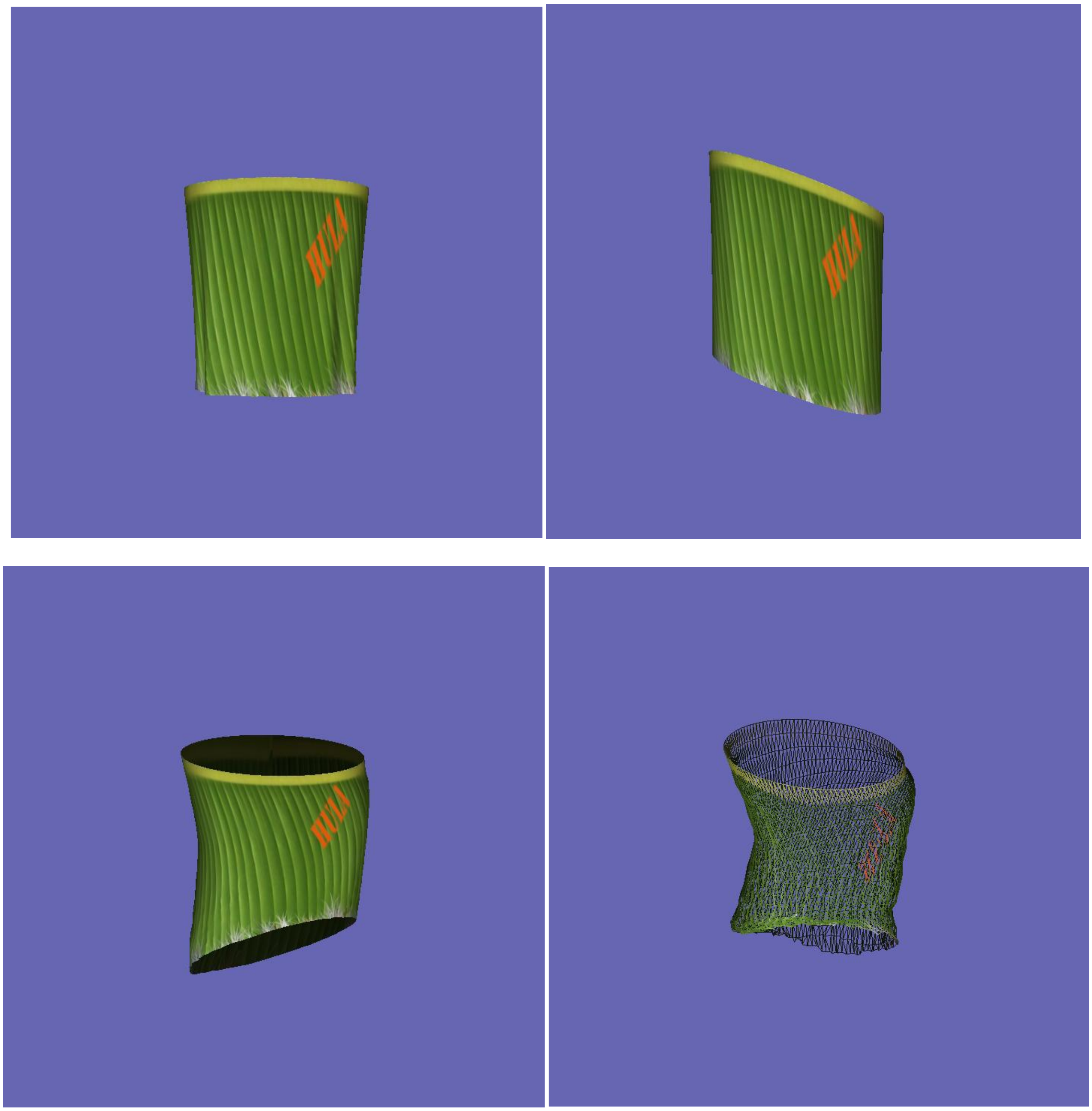
Equations

Hooke's Law: $F_s = k_s(L_C - L_R)$, where s stands for spring, L_C is the current length of the spring, and L_R is the length of the spring at rest.

$$\vec{a} = \frac{d\vec{v}}{dt};\ \vec{v} = \frac{d\vec{p}}{dt};\ \vec{p} = \int \vec{v}dt$$

Results

The result is a very satisfying physically based animation simulating a skirt in motion as shown in the below images.



For a video demo and more information, please consult the accompanying webpage.