CPSC 533B Assignment 4 *Cloth Draping over an Object* **Due Mar. 4, 2004**

1 Implementation

Your program should read in a triangle mesh defining the rest pose of a piece of cloth above the plane. Sitting beneath the cloth on the plane will be some other piece of fixed geometry represented by a level set (also read in by your program).

The cloth will drop according to gravity and come to rest draped over the object and the ground. You will then need to do collisions with the particles and the object geometry (exactly the same way you did in assignment 2, only this time with just inelastic collisions). For this assignment, you do not need to do cloth self-collision - it's okay if the cloth mesh ends up self-intersecting.

You will need to read in (as parameters) the cloth density (kg/m^2), the approximate cloth Young's modulus (N/m), the planar cloth damping (N per m per (*strain* per s), which is just Ns/m), the strain limit (dimensionless), the cloth bending stiffness (J per $curvaturesquared$ per m^2, which is just $J = Nm$), the cloth bending damping (Ns), and the cloth friction (dimensionless). Note that we're not modeling the cloth thickness here, but it is implicit in these parameters: for example, the planar density that is specified (in kg/m^2) is the regular volume density (kg/m^3) multiplied by the cloth thickness.

From the parameters and the cloth mesh you will need to assign particle masses and spring constants. For the masses use the centroid-based finite volumes, so each triangle's mass gets split equally between its vertices. For the spring constants use the speed-of-sound heuristic, with the mass associated with a spring being $1/3$ of the mass of the incident triangles. You will also want to precompute other terms such as rest lengths needed for the force calculations.

For this assignment, you again only need to implement the explicit symplectic Euler method, though note that most cloth simulators nowadays use implicit integration instead. You will also need to implement strain limiting: loop through the mesh edges after each time step, and apply impulses (immediately changing the velocities and positions of the endpoints) to reduce the strain of an over-stretched edge to the allowed maximum.

You do not have to handle cloth buckling in this assignment: just use the regular spring force in compression. You also do not need to implement the implicit velocity smoothing following the collisions: just use the same algorithm (without the elastic part) from assignment 2.

There is example code provided, along with auxiliary programs for generating meshes and viewing the results. Note that the only place you need to actually add code is in the `example/` subdirectory. Also note that the mesh and level set file formats have not changed, so geometry from other assignments may be used for the object (or even the cloth).

2 Analysis

Derive a lower bound for the stable time step of symplectic Euler. (You will need this in your code) As in assignment 2, this doesn't have to be particularly tight.

Derive how to compute the impulses that return an over-stretched spring to its maximum length based on a given maximum strain.

Assuming a simple continuous material—not woven cloth, but something more like a bendy plastic sheet—explain loosely why there is a resistance to bending, and approximately how it depends on the material thickness.

3 Project Ideas

You can extend this assignment in a number of ways for your final project, for example:

- implement both subgrid buckling (reducing the resistance to compression of the springs significantly) and enforced buckling (applying corrective impulses to re-extend any compressed springs) and compare

- accelerate collision detection
- switch to implicit integration
- handle self-collisions (this is difficult)
- make a mesh of an item of clothing, around a simple character, and move the character (e.g. spin it around)
- add wind forces on the triangles (this is a bit different than the wind drag of assignment 2) and attach the cloth to something to prevent it from blowing away
- replace the cloth with a three-dimensional elastic solid