Programming #4: Part III (4190.410)

Due: December 3, 2014

Part I: In this assignment, you will implement an interactive program that constructs a generalized cylinder. First, we define a cubic Bézier curve $C(t) = (x(t), y(t), 0)$, $0 \leq t \leq 1$, in the xy-plane and a circle of radius $r(t)$: $O_r(\theta) = r(t)(\cos\theta, \sin\theta)$, $0 \leq \theta \leq 2\pi$, defined in the uv-plane. The cross-sectional plane containing $O_r(\theta)$ is rotated so that the v-direction matches the z-direction and the u-direction matches $(0, 0, 1) \times T(t)$, where $T(t) = \frac{C'(t)}{\|C'(t)\|}$ is the unit tangent direction of $C(t)$. After that, the cross-sectional plane is translated by $C(t)$. The result is a tube-like surface that is generated by sweeping the circle $O_r(\theta)$ along the skeleton curve $C(t)$. The radius function $r(t) > 0$ may also be represented as a cubic Bézier function of t.

Part II: Implement an interactive program that constructs a generalized cylinder. First, we define a cubic Bézier space curve $C(t) = (x(t), y(t), z(t))$, $0 \leq t \leq 1$, and a circle of radius $r(t)$: $O_r(\theta) = r(t)(\cos\theta, \sin\theta)$, $0 \leq \theta \leq 2\pi$, defined in the uv-plane. The cross-sectional plane containing $O_r(\theta)$ is rotated so that it is orthogonal to the curve tangent direction $T(t) = \frac{C'(t)}{\|C'(t)\|}$. For this purpose, use a Householder matrix $H = I - 2\frac{\mathbf{v}\mathbf{v}^T}{\|\mathbf{v}\|^2}$, where $\mathbf{v} = T + (0, 0, 1)$. The details will be discussed in class. After that, the cross-sectional plane is translated by $C(t)$. The result is a tube-like surface that is generated by sweeping the circle $O_r(\theta)$ along the skeleton curve $C(t)$. You can control the shape of $C(t)$ by dragging its control points projected onto the xy, yz, and zx-planes.

For this programming assignment, you will also Implement a spherical environmental mapping to the generalized cylinder. Assuming the radius function $r(t)$ is almost constant, the unit normal N can be approximated by rotating the normal of the cross-sectional circle $O_r(t)$.

Part III: Implement a simple dampled oscillation effect for your generalized cylinder. After modeling a generalized cylinder at a static pose, you can drag some control points of $C(t)$ to new locations. Then release the control points and make each control point oscillate about the original position with damping.