Programming Assignment #2

Keyframing System for Animation and Sweep Surface

This programming assignment requires the implementation of a simple keyframe-based system for animation and sweep surface generation. The assignment is intended to let you practice with spline interpolation, B-splines, and Catmull-Rom splines. A sweep surface is defined by a sequence of cross section curves. You are first required to create a cross section curve using either closed B-splines or cubic interpolating splines. Then, a sequence of transformations (scaling + rotation + translation) is defined to bring cross sections at desired 3D locations. A smooth sweep surface can be constructed to interpolate those cross sections using three Catmull-Rom splines that interpolate scaling factors, orientations, and positions of the cross sections. The sweep surface should be displayed either as a polygonal mesh or by animation.

We will provide you with math library codes that include positions, vectors, matrices, transformations, quaternions and related operations. Linear system solvers (LU decomposition, Gauss-Seidel, conjugate gradient) are also included. The construction of Catmull-Rom splines for quaternions should be done as explained in the class.

Requirement

1. You will describe the control points of the cross section and transformations in the data file. The format is explained at the end of this assignment description. Your system should be able to parse the standard format.
2. You will construct a closed curve using either B-splines or cubic spline interpolation depending on what the data file demands. With spline interpolation, you will get a closed curve that passes through given control points. B-splines will not interpolate the control points in general.
3. You will describe a sequence of transformations in the data file. Each transformation represents scaling, followed by rotation, followed by translation. Applying the transformations to the curve defined at step 2, a sequence of cross sections are defined.
4. You will construct a time-varying transformation T(t) using Catmull-Rom splines. You are required to construct three splines for scaling factors, unit quaternions, and 3D positions. Then, the cross section at arbitrary time t can be computed simply by applying T(t) to the control points of the curve defined at step 2.

5. You will display the sweep surface either as a polygonal mesh or by animation. In both cases, your system should generate a dense sequence of in-between frames between every pair of consecutive keyframes to visualize smooth surfaces and animations. The rendering should be styled to present the shape of the surface clearly.
6. Your system must allow for the user to rotate the scene so that we can inspect your surfaces and animations at different view points.
7. You are required to create your own swept surfaces that are aesthetically pleasing.
8. You are required to write and submit a report of less than three A4 pages. This report should describe how you implemented, what you have done, and what you haven't done.

Data file format

```
SURFACE       # Display option (SURFACE or ANIMATION)
BSPLINE       # Curve type (BSPLINE or INTERPOLATION)
7             # The number of control points of the cross section.
10 10         # The 2D position of control points
20 15         # The coordinates of the cross section is defined within X-Z
…             # plane
8             # The number of keyframes
1             # The scaling factor at the first frame
1.2 1 0 0     # The orientation of the first keyframe
              # represented by a rotation about axis (1,0,0) by angle 1.2
10 50 30      # The position of the first keyframe
0.8           # The scaling factor at the second frame
0.5 0 1 2     # The orientation of the second keyframe
20 10 40      # The position of the second keyframe
…
```