Johns Hopkins
Engineering for Professionals

605.767 Applied Computer Graphics

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Module 6I
Uses of Parametric Curves and Surfaces

Uses of Parametric Curves and Surfaces

- Primary use is in modeling and design
  - Need to build objects from scratch and/or edit and modify the shape of existing representations
- Several techniques for building and interacting with parametric curves and surfaces have been developed:
  - Interpolation of data sets using B-splines
    - Fitting a B-spline curve to a set of data points
  - Surface fitting
  - Cross-sectional design or sweep representations
  - Control polyhedron design: free-from sculpting

Interpolation Using B-splines

- Modeling: fitting a set of data points
  - Can then store and manipulate the spline surface
    - More compact than a large set of data points
- Animation: use a parametric curve to represent the path of an object or camera through space
  - Define a set of positions called **key frames**
    - Fit a curve through the key frame points
    - The curve provides smooth motion as a function of time
- Two primary methods:
  - Uniform parameterization
    - Ignores geometric relationship between points
    - A poor interpolation
      - However, it is invariant under affine transformations
  - Chord length parameterization
    - Sets knot intervals in proportion to distance between data points
      - Creates a matrix representing a system of equations to solve for the control points

Surface Fitting

- Technique for interpolating a set of three dimensional data points with a parametric surface
  - Convert to a net of Bezier patches using B- spline curve interpolation and conversion from B-spline to Bezier
- Fit a network of uv curves through the data points
  - Using B-spline interpolation techniques
- Convert B-spline curves to Bezier curves
- Partition into individual mesh elements
  - Formed from four Bezier curve segments
  - These are the boundary edges of a Bezier patch
    - Can derive the control points for the patch

Sweep Representations

- Solids modeling packages often provide **sweep representations**
  - Useful for modeling objects that possess symmetry (rotational, translational)
  - Also called cross sectional design
- Constructing a solid by specifying cross sections and intervals along a sweep or curve
  - Linear axis design: surfaces of revolution
    - Sweep a curved cross section (spline) along a straight line
  - Rotational sweep
    - Spline representation is rotated about an axis specified in the plane of the cross section
  - General sweep constructions
    - Can sweep along any path
    - Can vary the shape or size of the cross section along the path

Control Polyhedron Design

- This is a method to perform free form **sculpting** of parametric surfaces
  - Move control points
    - Raise / lower local surfaces areas
  - Modeling approach described in most textbooks
- What if interacting with a set of surface patches rather than a single patch?
  - Continuity issues must be considered
- Locality and scale of control
  - Fine control
    - Limiting control so that fine adjustments affect a small enough part of the surface
    - Technique known as **hierarchical B-spline deformation** can be used
  - Coarse control
    - Sometimes need to operate on a large set or all control points simultaneously