

Surface Representation / Meshes

EN193s08 3D Photography
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Gabriel Taubin

3D Representations

- Volumes (solid objects)
- Surfaces (boundaries of solids)
- What is a 3D Representation ?
 - Computer memory is finite
 - Approximation defined by finite number of parameters
 - Efficient to perform certain operations (transmit, render, etc.)
 - Data structures

Surface Modeling

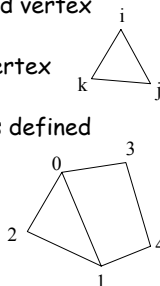
- Polygon meshes
 - Planar subdivisions
 - Set of connected polygonally bounded planar surfaces
- Parametric surfaces
 - Curved surfaces
 - Piecewise polynomial : Bezier patches / Splines
- Implicit surfaces
 - Iso-surfaces
 - How to convert to polygon mesh ?

Polygon meshes

- Simplest case: triangle mesh
- Triangle defined by 3 vertices in 3D
 - Vertex specified by 3 (x,y,z) coordinates
 - 9 floats per triangle
 - No connectivity
 - STL file format
 - used for rapid prototyping applications
 - Inefficient for other operations

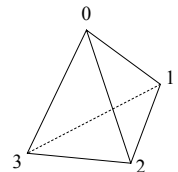
IndexedFaceSet

- Array of vertex coordinates
- Each 3D vertex has an associated vertex index in $\{0, \dots, V-1\}$
- A triangle is defined by three vertex indices (i,j,k)
- A polygonal face without holes is defined by more indices
- coordIndex [0,1,2,-1,0,3,4,1,-1]
- VRML'97 file format



Tetrahedron.wrl

```
#VRML V2.0 utf8
Shape {
  geometry IndexedFaceSet {
    coord Coordinate {
      point [
        1.633 -0.943 -0.667
        0.000 0.000 2.000
        -1.633 -0.943 -0.667
        0.000 1.886 -0.667
      ]
    }
    coordIndex [
      0 1 2 -1 3 1 0 -1 2 1 3 -1 2 3 0 -1
    ]
  }
}
```



Classification

- Connectivity
 - coordIndex (faces)
- Geometry
 - coord (vertex coordinates)
- Properties
 - color/colorIndex/colorPerVertex
 - normal/normalIndex/normalPerVertex
 - texCoord/texCoordIndex

Connectivity

- Edges
 - Boundary (1 incident face)
 - Regular (2 incident faces)
 - Singular (3 or more incident faces)
- Vertices
 - Regular / Singular
- Connected components
 - Connected Components of Dual Graph

Manifold / Non-Manifold

- Data structures to represent
- Traversal Operations
- Algorithm to generate representation from IndexedFaceSet

Curved surfaces

- Parametric curves
 - $p(t) = (x(t), y(t), z(t))$ t in $[0,1]$
- Parametric surfaces
 - $p(u,v) = (x(u,v), y(u,v), z(u,v))$ (u,v) in $[0,1] \times [0,1]$
- Triangle patches
 - Affine coordinates, partition of unit
 - Bezier surfaces
- Subdivision surfaces

Interpolation

- Linear interpolation
- Triangle : Baricentric coordinates
 - Triangle
 - Tetrahedron
- Quadrilateral ?
 - Bi-linear interpolation
- Cube ?
 - Tri-linear interpolation

Subdivision surfaces

- Limit of sequence of polygonal meshes
- Representation
 - Base mesh
 - N subdivision steps
 - Connectivity refinement
 - Smoothing
- Approximation vs. Interpolation
- Proof of convergence
- Loop / Catmull-Clark
- Dual mesh / Doo-Sabin

Operations on meshes

- Construction of triangle strips
- Subdivision
- Intersection
- Rendering (rasterization/sampling)
- Conversion to Manifold
- Simplification / Decimation

Doubly-linked data structure

- Planar subdivisions
- Planar graph embedding
- Vertices / Faces / Half-Edges
- Orientation