CMSC427 Lecture Notes fall 2017
Polygonal mesh outline
Class 4&5: Thursday, Sept. 7th and Tuesday, Sept. 12th

Topics::

I. Parametric surfaces
- A. From 2D curves to 3D surfaces
  - 2D curves: mapping $R \to R^2$ from t to x,y plane (s also used)
  - 3D curves: mapping $R \to R^3$ from t to x,y,z space
  - 3D surfaces: mapping $R^2 \to R^3$ from u,v plane to x,y,z space
  - A 2/3D curve is a one dimensional object; a 3D surface is a two dim. object
- B. Example: bilinear patches (blending two lines)
- C. Example: Coons patches (blending two arbitrary curves)
- D. Example: Cone (extruding circle or lathing line)
- E. Example: Cylinder (extruding cone or lathing line)
- F. Note: Object vs. world coordinates
  - Object coordinates are natural coordinates to use for drawing a given shape. We use the simple curve and surface equations centered at origin because it's easier, and we can move, rotate and scale shape afterwards.

  Circle at origin: x^2+y^2 = r^2 Prefer this.
  Circle at (cx,cy): (x-cx)^2 + (x-cy)^2 = r^2

  Instead of using second equation, use first and translate to (cx,cy) afterwards.

II. Polygonal meshes
- A. Introduction
  - Free viewing software: Meshlab (http://www.meshlab.net)
  - Sources of 3D mesh models:
    - SketchFab (https://sketchfab.com)
    - Thingiverse (https://www.thingiverse.com)
    - Stanford repository (http://graphics.stanford.edu/data/3Dscanrep/)
    - Examples: Utah teapot, Stanford bunny
- B. Basics of polygonal mesh
  - Geometric components: vertex and normal list
  - Topological component: face list
  - Vertex vs. face normals
  - Order of vertices on a face
  - Example: tetrahedron
- C. Properties of polygonal meshes
  - Topological properties
    - Vertex properties: valance or vertex degree (# of incident edges)
      regular (connects polygons in fan)
      singular (connects polygons with gaps)

Edge properties: boundary edge (adjacent to exactly one face)
regular edge (adjacent to exactly two faces)
singular edge (adjacent to more than two faces)

Face property: orientation (clockwise or counter clockwise around intended outward normal)

Mesh property: Manifold if no singular vertices or edges
Closed if all edges are regular (or interior)
Orientable if you can orient each face correctly

D. File formats
STL, OBJ, and other polygonal mesh files formats
Jargon term: polygon soup, a mesh or file that has isolated polygons

II. Generating a polygon mesh from procedural model: extruded shapes
A. Extruded shapes and prisms
B. Extruding a polygon by generating the additional vertex list, normals and faces

IV. Computing normal to faces
A. Cross product of face edges
Newell's method
B. Parametric (u,v) surface: cross product of partial derivatives
C. Implicit surface: gradient

V. Summary: methods of generating polygon meshes
A. Fixed shapes. Any shape based on idiosyncratic data, such as the exact shape of a stone, foot, sculpture, etc. All hard-coded, some from real world data collection
B. Regular polyhedron, such as cubes, tetrahedrons, icosahedrons, dodecahedrons, ...
C. Operations that create shapes
Extrusion
Lathing (surfaces of rotation)
Surface subdivision
D. Parametric shapes – bilinear patches, quadrics, superellipses, etc.
E. Fractal shapes – based on grammars, harnessed randomness, and so on

References:
Wikipedia: polygon mesh
https://en.wikipedia.org/wiki/Polygon_mesh
SIGGRAPH Polygonal mesh tutorial, Botsch et al 2008 (advanced, more on this later)
http://lgg.epfl.ch/publications/2008/botsch_2008_GMPeg.pdf