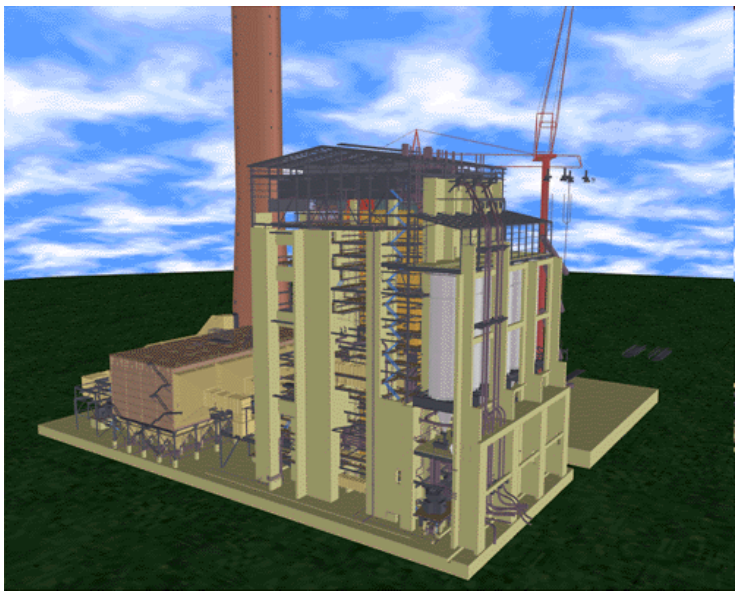
COMP 371 – Winter 2012
Computer Graphics

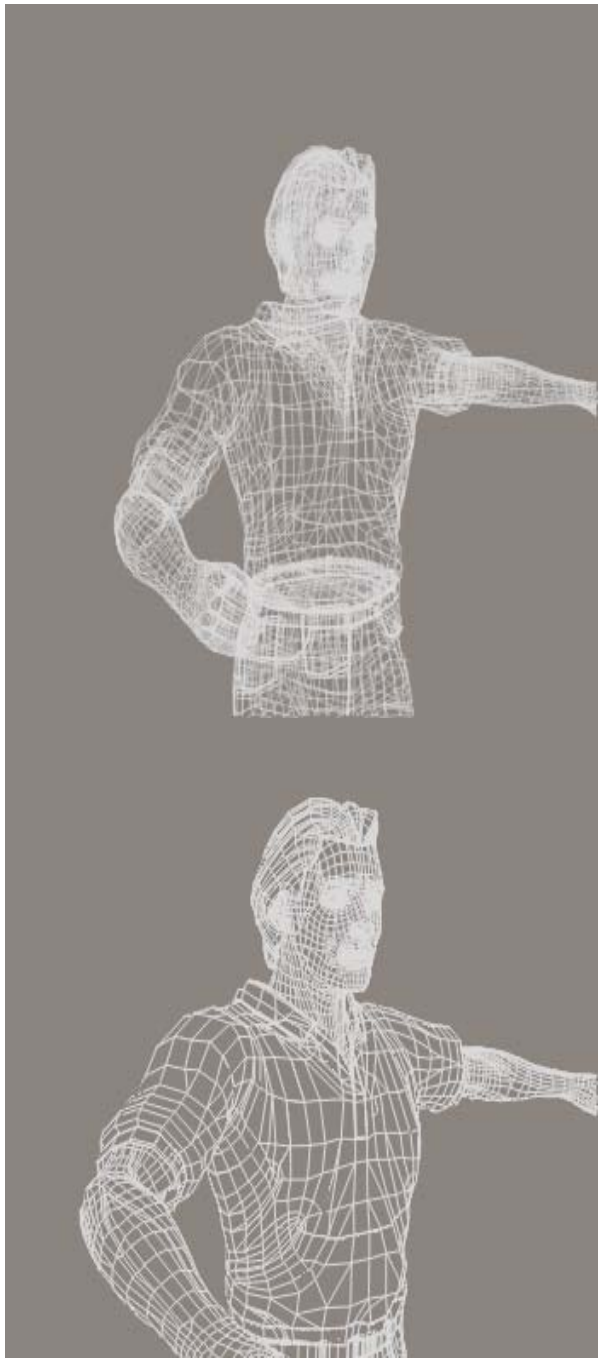
- 3D Object Modeling
- Delaunay Triangulation

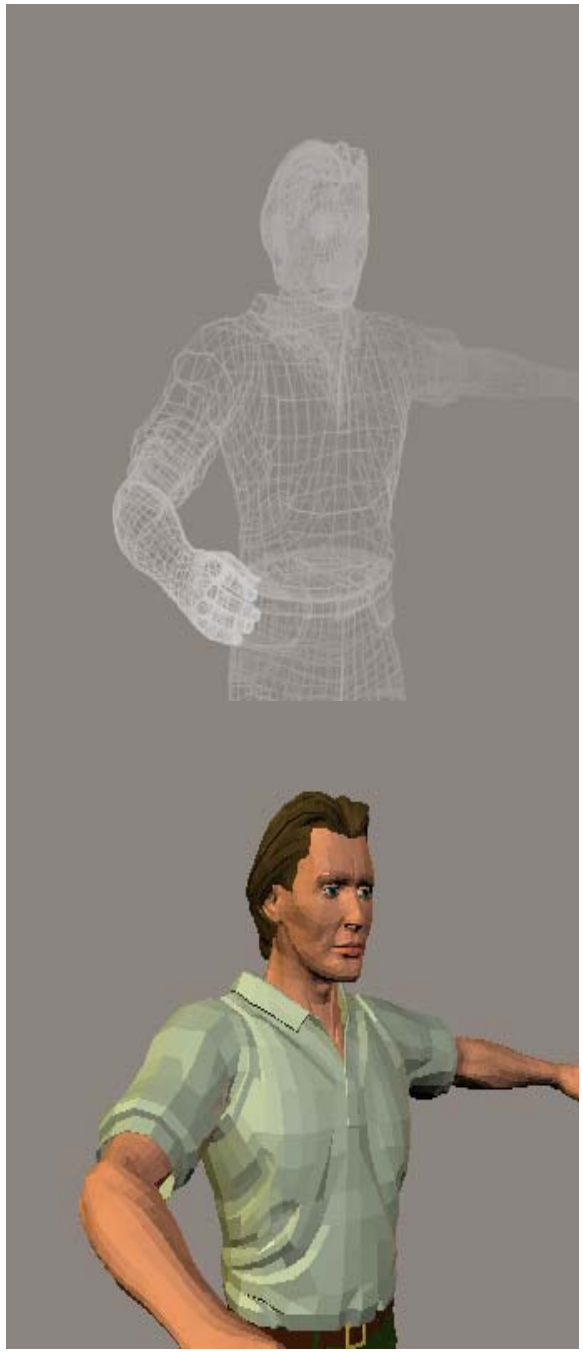
Outline of course

- Geometry
- Shading
- Texture mapping
- *Modeling*
- Animation

How to efficiently represent the geometry of scene objects, which may be complex, curved, etc.







Polygon Mesh

- A polygon mesh is a set of edges, vertices, and polygons connected such that each edge is shared by at most two polygons
  - Open boxes, cabinets, building exteriors

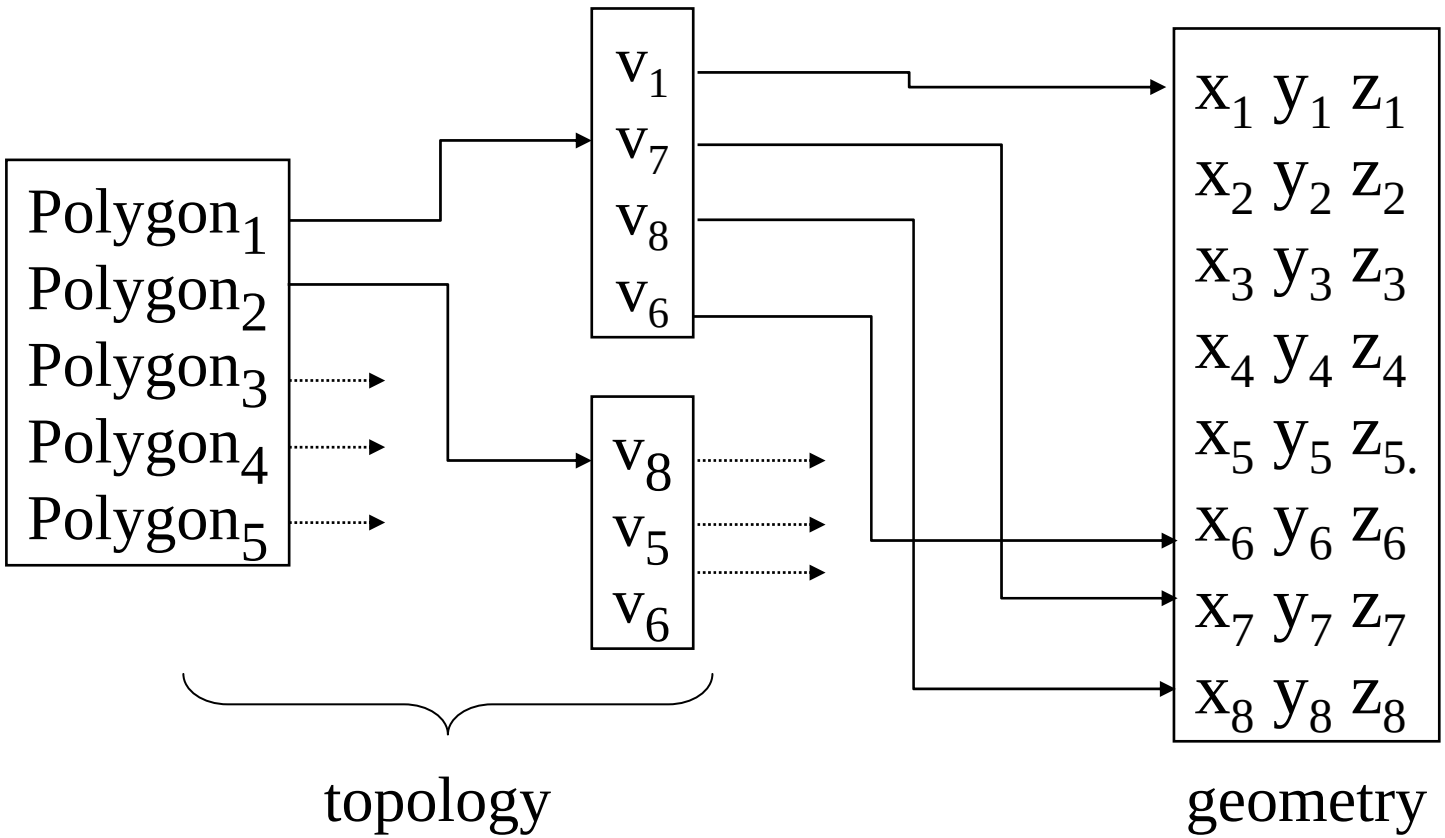
- Polygon meshes can be used to also represents objects with curved surfaces.
  - The error can be made arbitrary small by using more and more polygons to create a better piecewise linear approximation
  - However, the error becomes obvious if the image is enlarged

Geometry vs. Topology

- Generally it is a good idea to use data structures that separate the geometry from the topology
  - Geometry: locations of the vertices that form the mesh.
  - Topology: organization of the vertices and edges.
    Which vertices are connected to which other vertices.
- The topology holds even if geometry changes

Vertex Lists

- Put the geometry in an array and use pointers from the vertices into this array



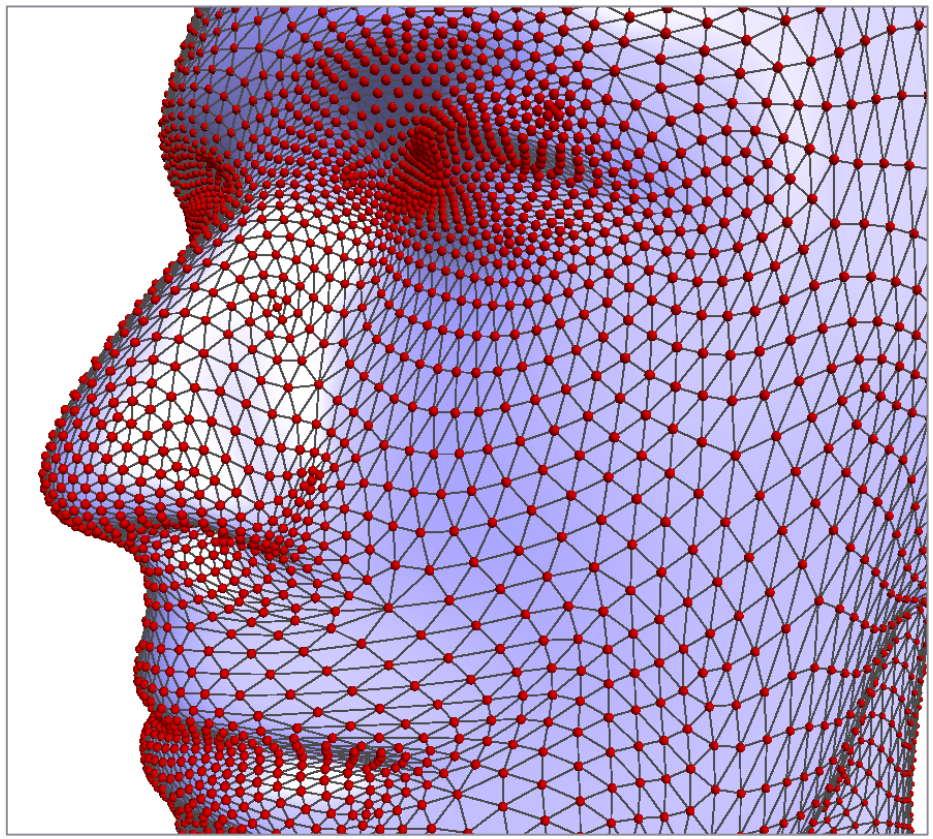
Triangle mesh

- Geometry:
  - Vertex coordinates

(x_1, y_1, z_1)
(x_2, y_2, z_2)
. . .
(x_n, y_n, z_n)

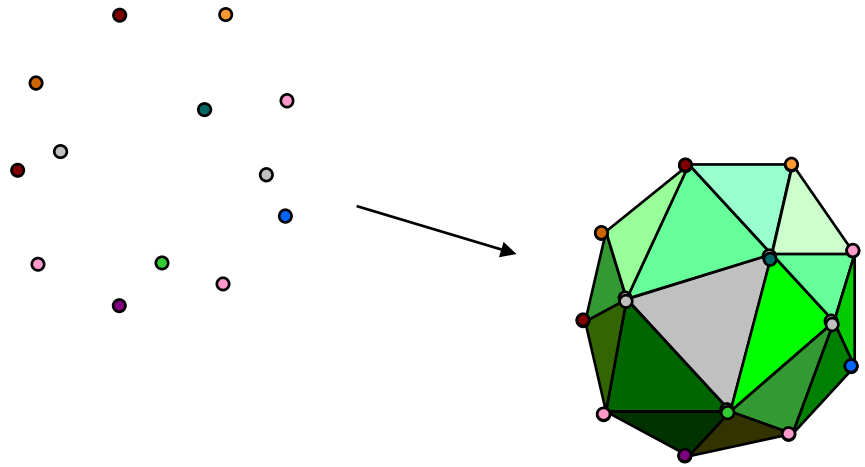
- Connectivity (the graph)
  - List of triangles

(i_1, j_1, k_1)
(i_2, j_2, k_2)
. . .
(i_m, j_m, k_m)



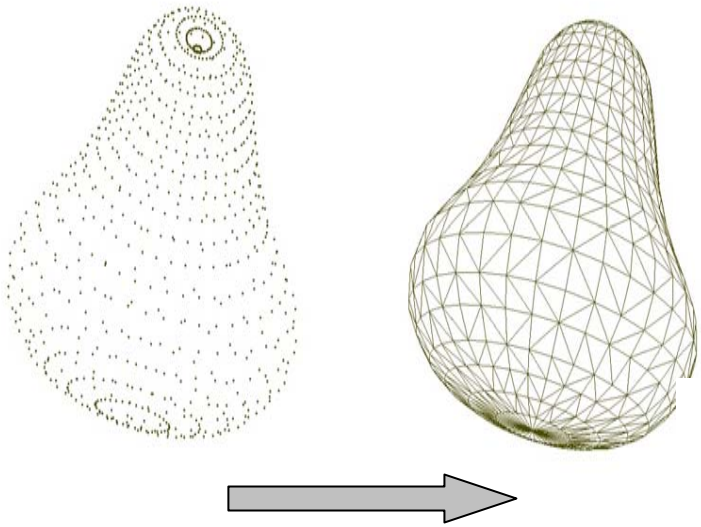
Samples and connectivity

- Samples (“vertices”)
  - Location (x,y,z)

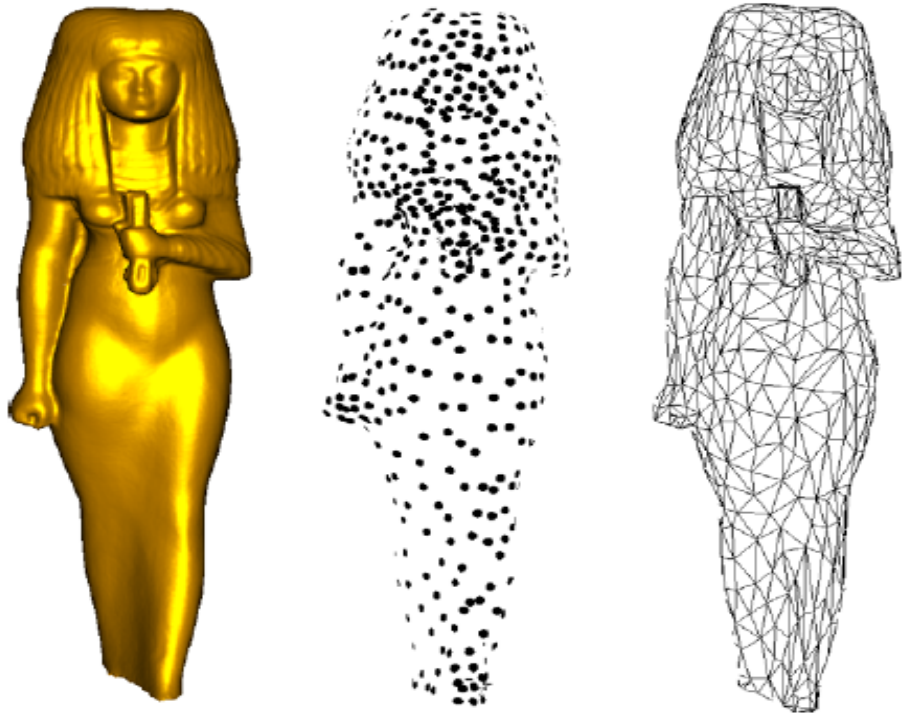


- Connectivity (“triangles”)
  - Define how surface interpolates samples
  - Specifies surface as a set of **triangles**
  - Associates each triangle with 3 samples

Samples and Reconstruction



Surface Reconstruction Algorithm

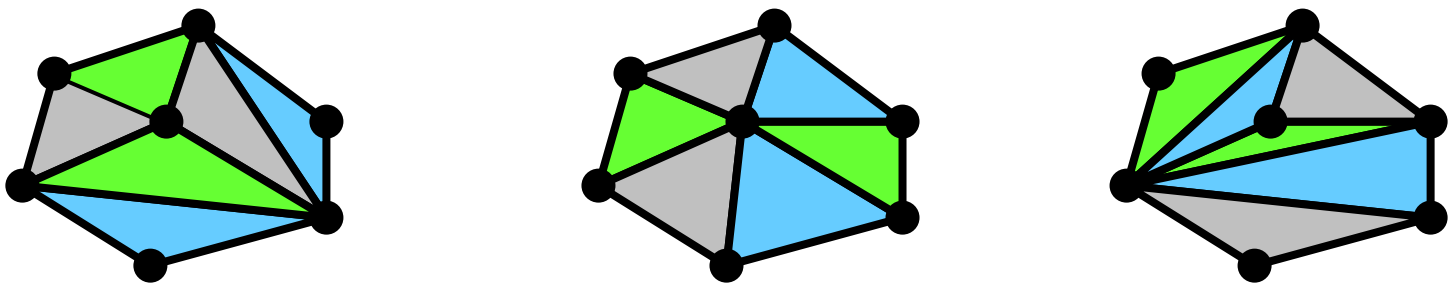


Triangulation

- Triangulation is a problem in Computational Geometry. The objective is to break down an object into simple geometric shapes: triangles (in 2D).
- Typical application of triangulation: surface interpolation. This means, if we have the height of a mountain at a certain number of points on the plane, how do we estimate the height at any point?
- Terrain Modeling

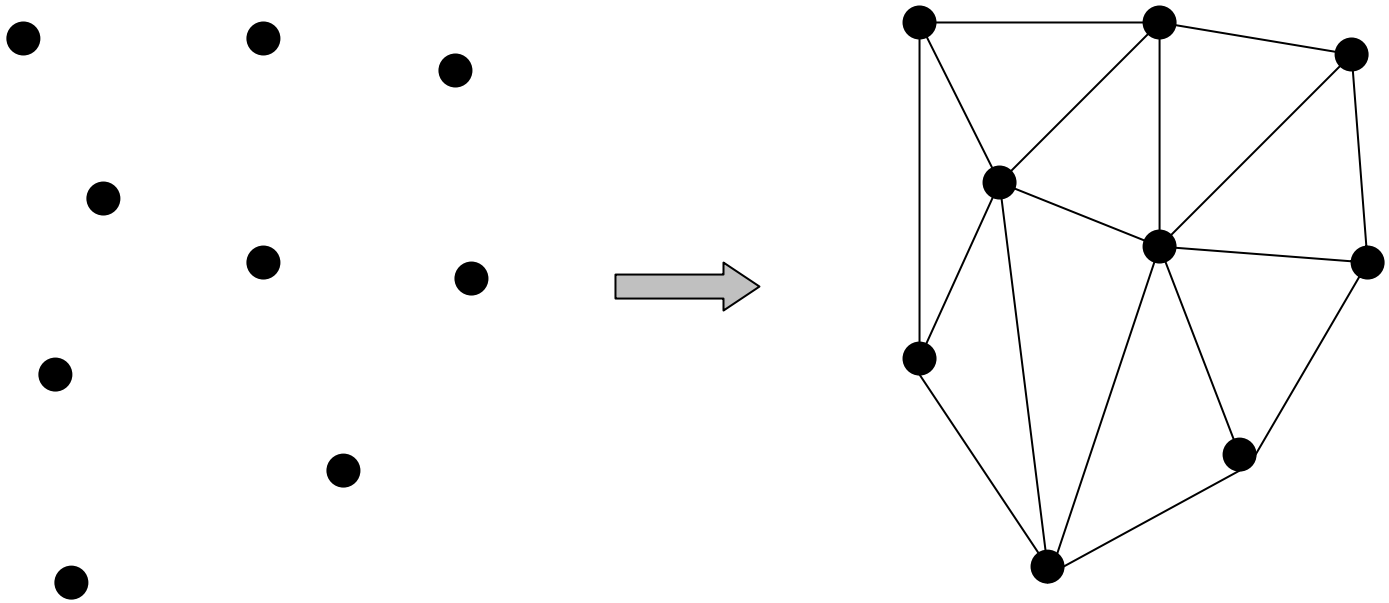
  http://astronomy.swin.edu.au/~pbourke/terrain/triangulate/

There are an exponential number of triangulations of a point set.



Delaunay Triangulation

- **Input:** Set of points in the plane
- **Output**: Delaunay Triangulation

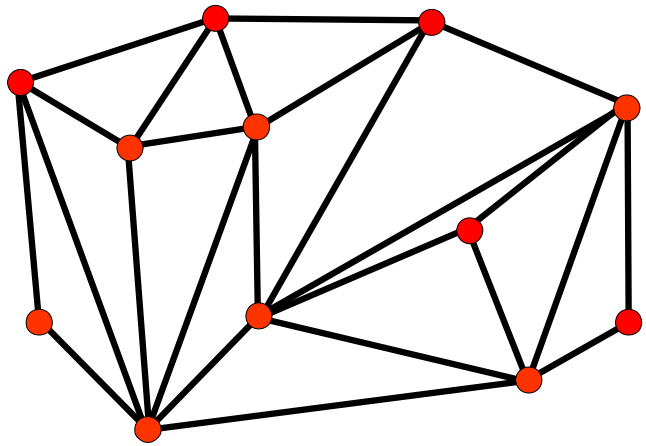


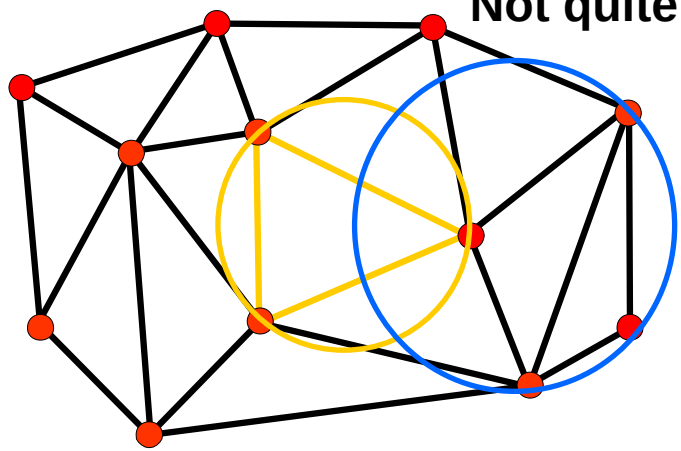
Triangulation

A *triangulation* is a straight line plane graph whose faces are all triangles.

A *Delaunay triangulation* of a set of points is the unique set of triangles such that the circumcircle of any triangle does not contain any other point.

The Delaunay triangulation avoids long and skinny triangles.





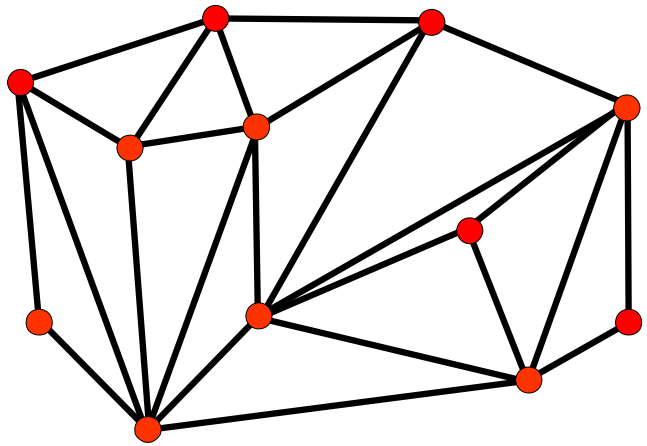
Not quite yet…

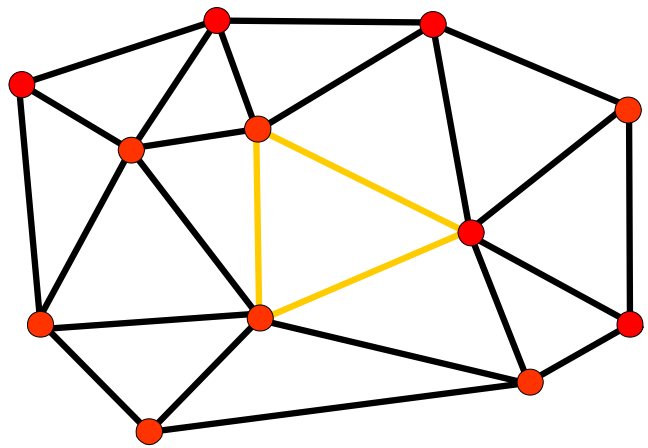
Triangulation

A *triangulation* is a straight line plane graph whose faces are all triangles.

A *Delaunay triangulation* of a set of points is the unique set of triangles such that the circumcircle of any triangle does not contain any other point.

The Delaunay triangulation avoids long and skinny triangles.

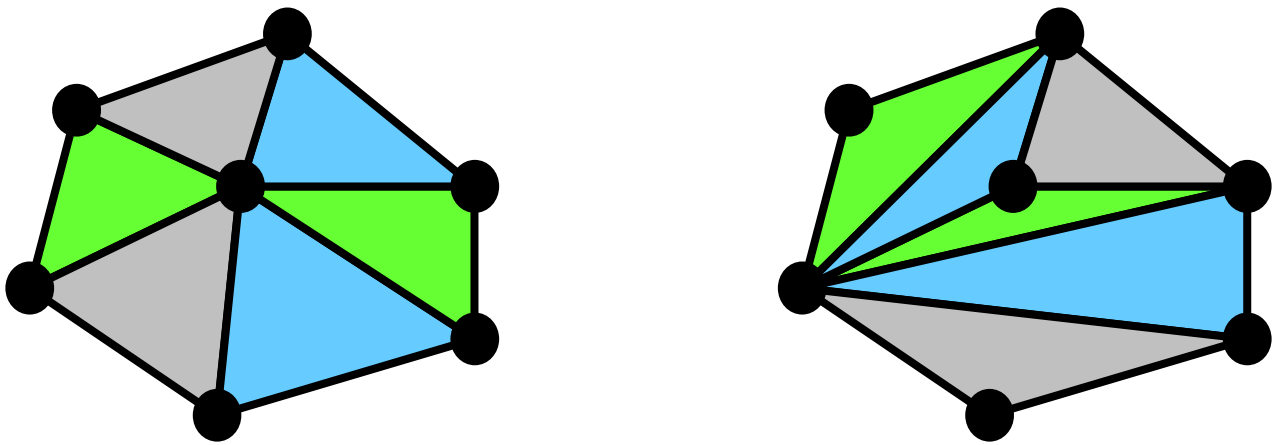




Now Delaunay

“Quality” Triangulations

- Let $\alpha(T) = (\alpha 1, \alpha 2, ..., \alpha 3t)$ be the vector of angles in the triangulation T in increasing order.
- A triangulation $T1$ will be “better” than $T2$ if $\alpha(T1) > \alpha(T2)$ lexicographically.
- The Delaunay triangulation is the “best”.

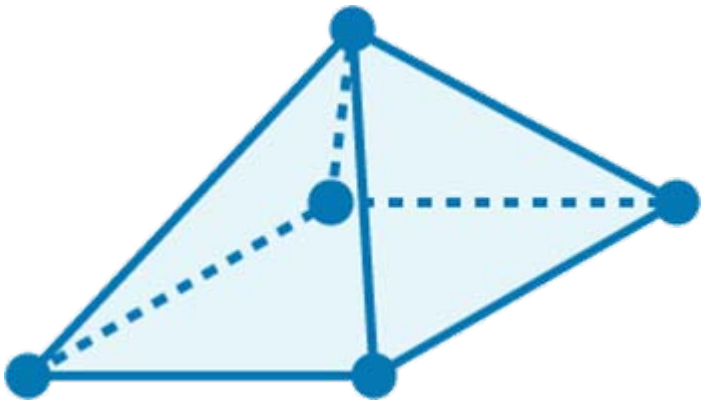


good

bad

3D Surfaces

- Geometry, color, texture
- 3D scanning
- Polygon meshes
- Problem - *large data sets*



Some 3D Formats

- 3DS: 3D-Studio File Format.
- OBJ: Wavefront .obj file format specification for the Advanced Visualizer software.
- DXF: AutoDesk/AutoCAD interchange format in the various format versions that have appeared over the years.
- PLY: Polygon File Format also known as the Stanford Triangle Format.
- STL: Industry standard format for stereoLithography.
- VRML: The Virtual Reality Modelling Language.

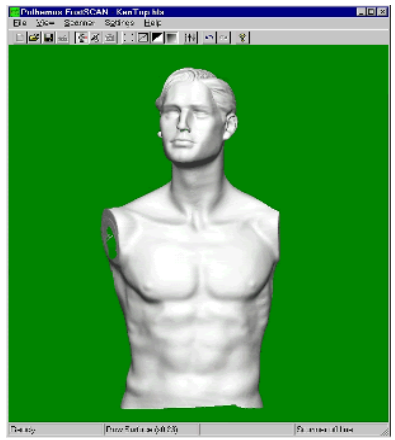
A typical CAD drawing (of a money clip) ready to be rendered on the 3-D printer.

Creating the Surface Points

- Triangulation works on a set of points
  - One needs to create this surface point set
- Many different approaches:
  - Manual placement
  - Mathematical (geometrical) generation
  - Scanning real objects

Hand-held laser scanner

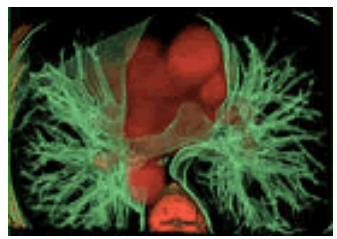
Recovered 3D model



- Laser scanning (3D Scanners)
- Tomographic methods
  - Medical scanning (X-ray, CT, MRI)
  - Radar

Slice of brain from CT scan

Recovered 3D model of lungs

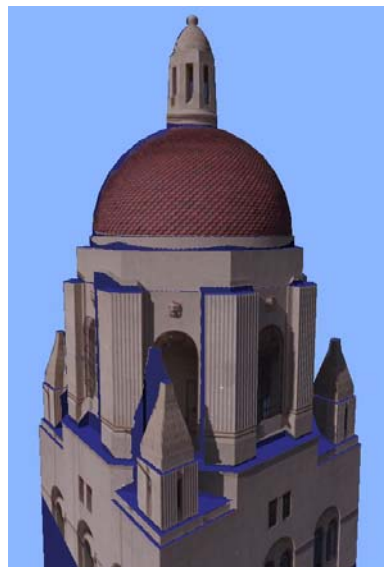


Scanning Real Objects

- Computer vision (3D reconstruction)

Actual photograph of Hoover Tower

Recovered 3D model



Model rendered from novel view and texture mapped