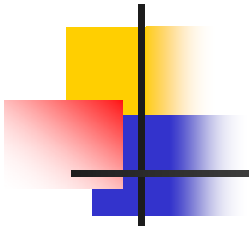
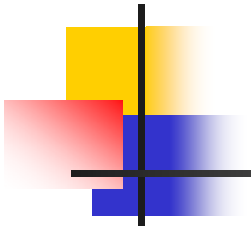


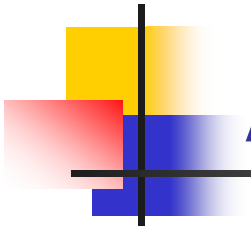
# Geometric Modeling

- How to design a graphical model?
  - Design
- How to create a digital description of a real-world object?
  - Digitize



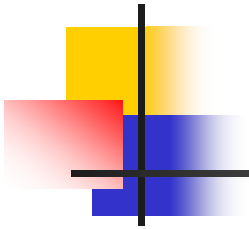
# By other names

- Data Generation
- CAD: Computer-Aided Design
- CAAD: Computer-Aided Architectural Design
- Geometric Modeling
- Computational Geometry



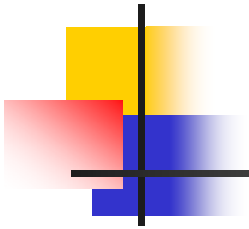
# Approaches

- interactive design
- procedural composition & construction
- CSG: constructive solid geometry & boolean operators
- subdivision surfaces
- fractals
- isosurfaces of implicit functions



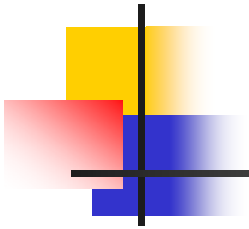
# Geometric Modeling Basics

- types of polygons & polyhedra
- computing normals
- geometric computations
- OpenGL concerns
- procedural approaches



# types of polygons & polyhedra

- triangle – fixed length polygons
- convex polygon / polyhedron
- concave polygon / polyhedron
- non-planar polygon
- sliver triangles – error-prone normals

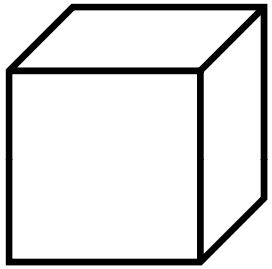


# Polygonal processing

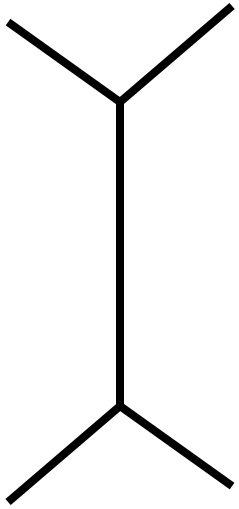
- triangulation
- converting to convex polyhedra
- intersection testing
- closure testing
- well-formed polyhedron:
  - closed,
  - non-self intersecting
  - 2D manifold

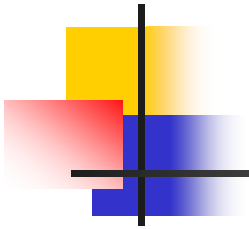
# Data structures

- face-based



- winged edge





# computing normals

- cross-product of edges
  - ordered edges at convex corner

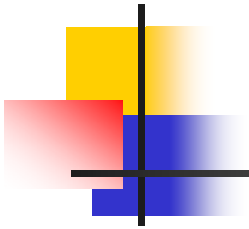
$$N = (v0 - v1) \times (v2 - v1)$$

- summation method

$$N_x = \sum ((z_i + z_{i+1}) \times (y_{i+1} - y_i))$$

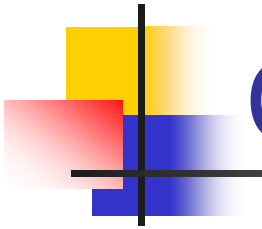
$$N_y = \sum ((x_i + x_{i+1}) \times (z_{i+1} - z_i))$$

$$N_z = \sum ((y_i + y_{i+1}) \times (x_{i+1} - x_i))$$



# computing vertex normals

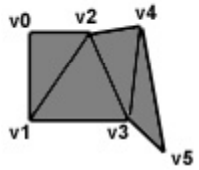
- for each vertex, i, n[i]=(0,0,0)
- for each face, j
  - Compute the normal, nrml, for the face
  - For each vertex, i, of the face n[i] += nrml
- for each vertex, I, normalize n[i]



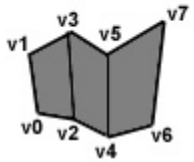
# OpenGL concerns

- vertex normals
- convex polygons

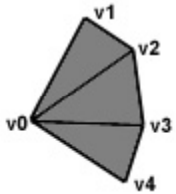
- triangle strip

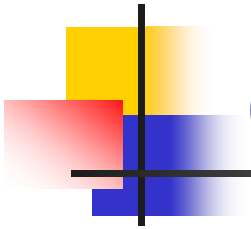



- quad strips



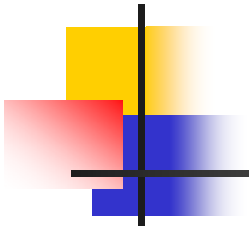

- triangle fans





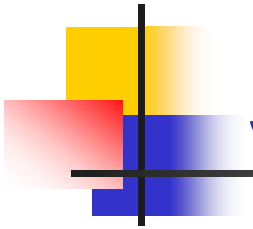
# geometric computations

- topology: genus, holes, & handles
- Euler's formula: E+2 = F+V+2G
- Convex hull
- distance to, contained in, intersected by
- meshing & simplification
- LoD: level of detail representations



# Procedural Approaches

- composition from primitive shapes
- extrusion
- solid of revolution
- lofting
- sweep operator

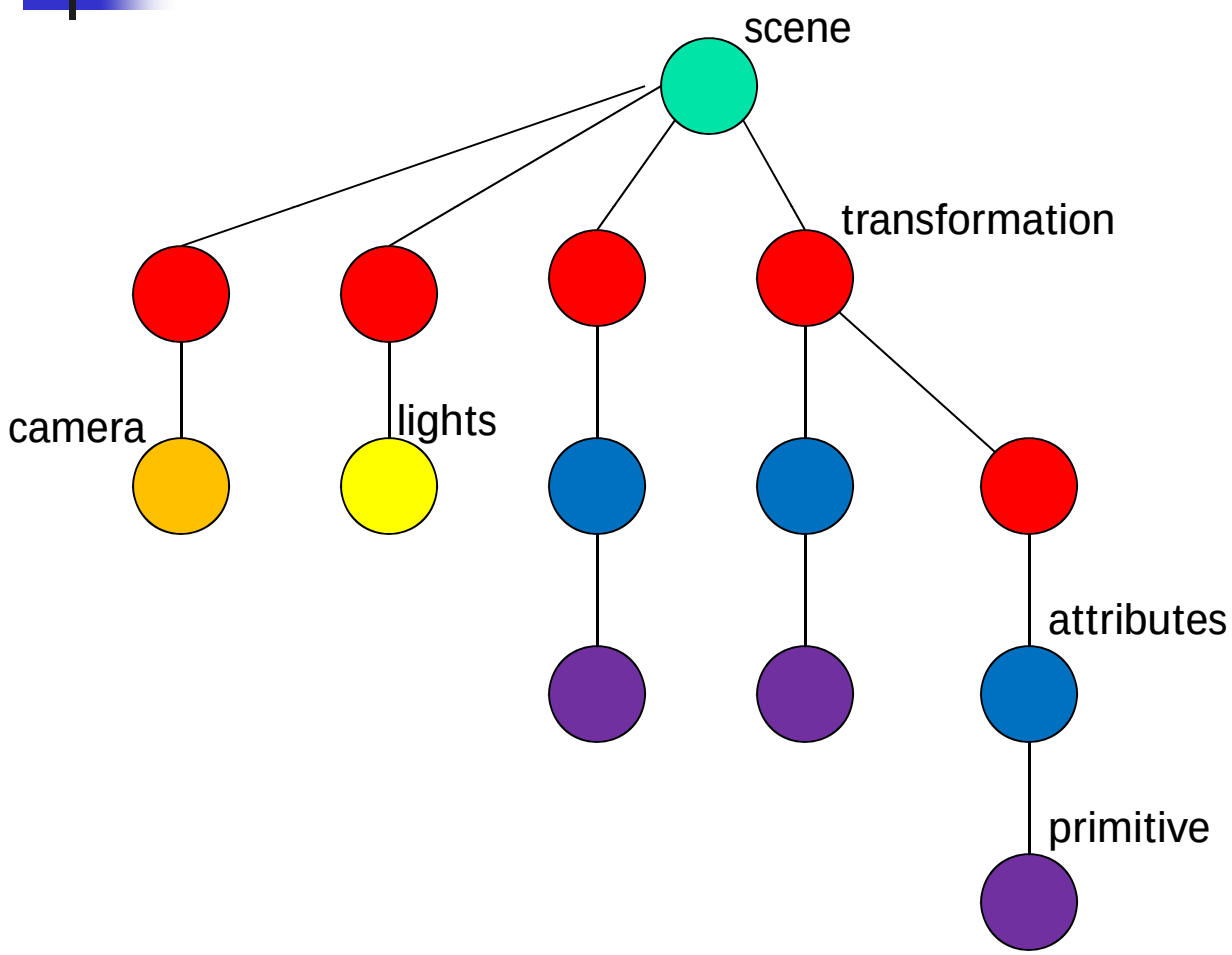


# Scene Graph

**Hierarchical representation**
**File format to record scene description**

- Describe a scene
  - transformations
  - primitive objects
  - attributes
  - camera
  - lights

# Scene Graph




```
Scene {
  transform {
    attribute
    primitive
  }
  transform {
    attribute
    primitive
    transform {
      attribute
      primitive
    }
  }
  ...
}
```