Lecture 2 (supplement)

Models, Architecture, Graphics Pipeline - 2

Graphics Hardware/Software Architecture

- Process objects one at a time in the order they are generated by the application
  - Can consider only local lighting
- Pipeline architecture

- All steps can be implemented in hardware on the graphics card

Figure from *Ed Angel, D. Shreiner: Interactive Computer Graphics, 6th Ed., 2012 © Addison Wesley*

Vertex Processing

- Much of the work in the pipeline is in converting object representations from one coordinate system to another
  - Object coordinates
  - Camera (eye) coordinates
  - Screen coordinates
- Every change of coordinates is equivalent to a matrix transformation
- Vertex processor also computes vertex colors

Figure from *Ed Angel, D. Shreiner: Interactive Computer Graphics, 6th Ed., 2012 © Addison Wesley*

Projection

- *Projection* is the process that combines the 3D viewer with the 3D objects to produce the 2D image
  - Perspective projections: all projectors meet at the center of projection
  - Parallel projection: projectors are parallel, center of projection is replaced by a direction of projection

Figure from *Ed Angel, D. Shreiner: Interactive Computer Graphics, 6th Ed., 2012 © Addison Wesley*

Primitive Assembly

Vertices must be collected into geometric objects before clipping and rasterization can take place

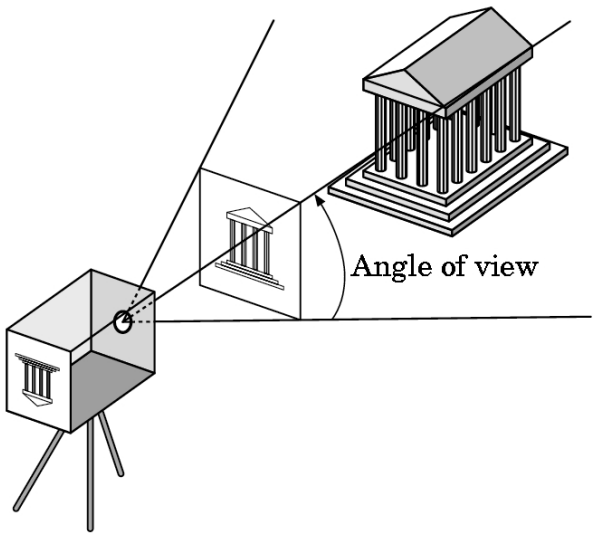
- Line segments
- Polygons
- Curves and surfaces

Figure from *Ed Angel, D. Shreiner: Interactive Computer Graphics, 6th Ed., 2012 © Addison Wesley*

Clipping

Just as a real camera cannot "see" the whole world, the virtual camera can only see part of the world or object space

- Objects that are not within this volume are said to be *clipped* out of the scene



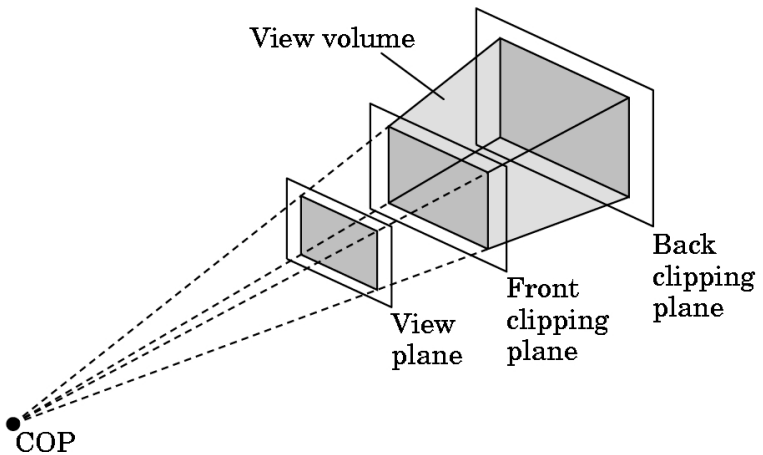


Figure from *Ed Angel, D. Shreiner: Interactive Computer Graphics, 6th Ed., 2012 © Addison Wesley*

Rasterization

- If an object is not clipped out, the appropriate pixels in the frame buffer must be assigned colors
- Rasterizer produces a set of fragments for each object
- Fragments are "potential pixels"
  - Have a location in frame bufffer
  - Color and depth attributes
- Vertex attributes are interpolated over objects by the rasterizer

Figure from *Ed Angel, D. Shreiner: Interactive Computer Graphics, 6th Ed., 2012 © Addison Wesley*

Fragment Processing

- Fragments are processed to determine the color of the corresponding pixel in the frame buffer
- Colors can be determined by texture mapping or interpolation of vertex colors
- Fragments may be blocked by other fragments closer to the camera
  - Hidden-surface removal

Figure from *Ed Angel, D. Shreiner: Interactive Computer Graphics, 6th Ed., 2012 © Addison Wesley*

Programmer's Interface

- Programmer sees the graphics system through a software interface: the Application Programmer Interface (API)

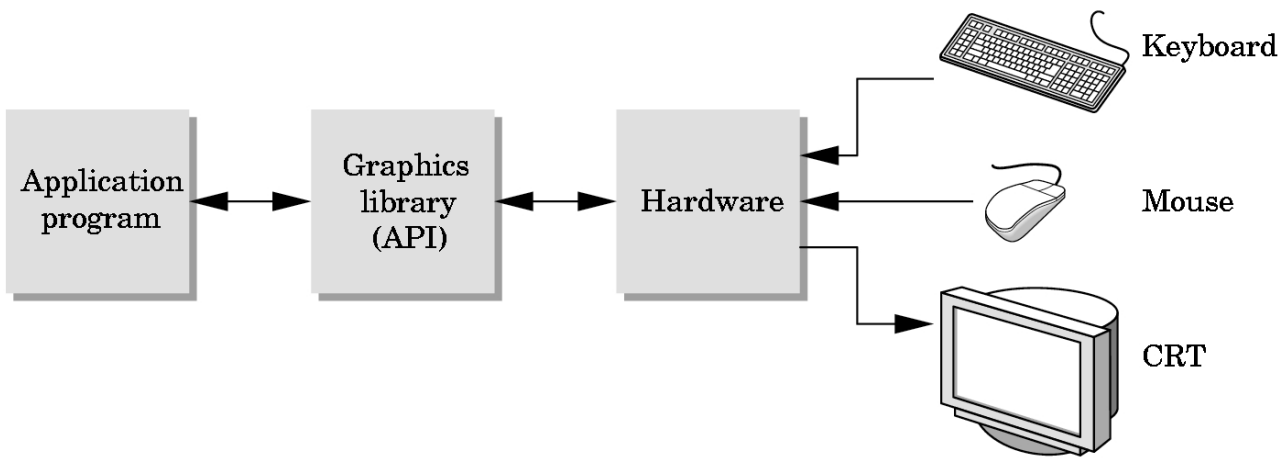


Figure from *Ed Angel, D. Shreiner: Interactive Computer Graphics, 6th Ed., 2012 © Addison Wesley*

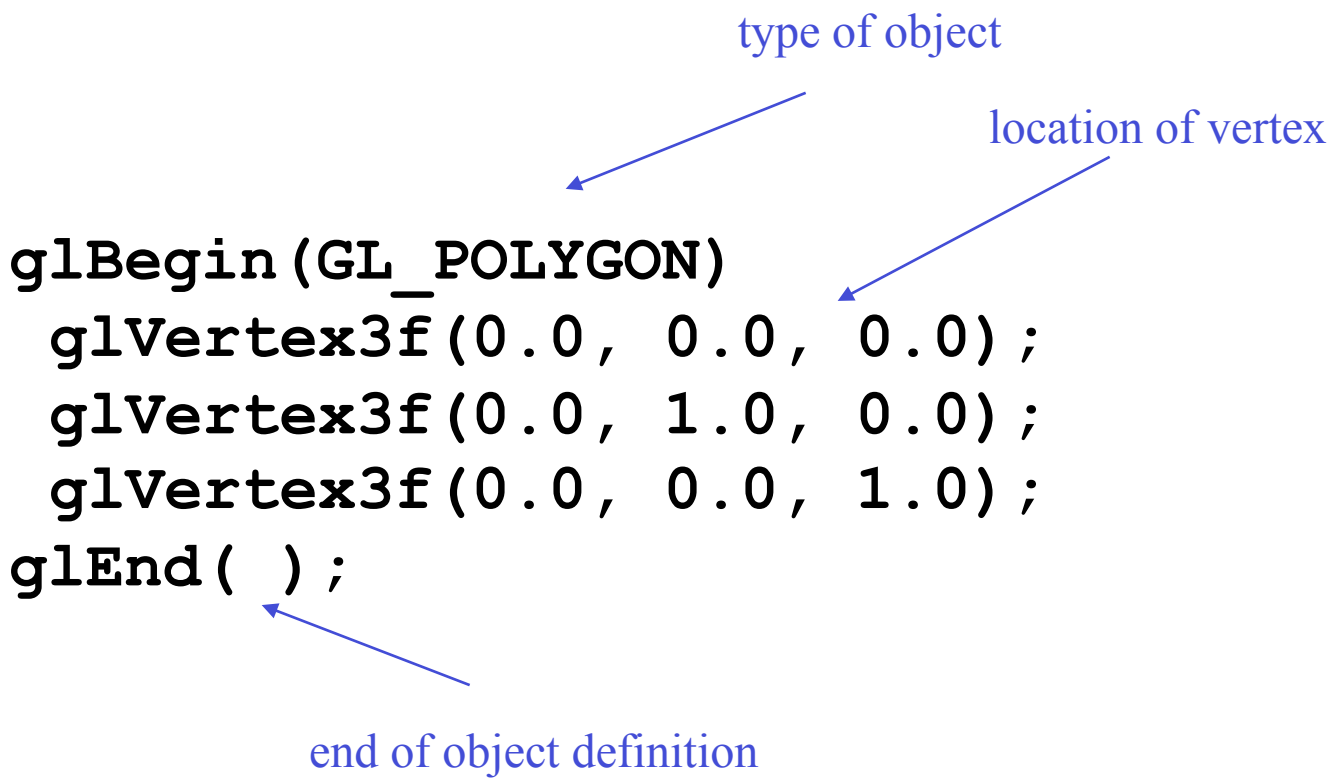
API Contents

- Functions that specify what we need to form an image
  - Objects
  - Viewer
  - Light Source(s)
  - Materials
- Other information
  - Input from devices such as mouse and keyboard
  - Capabilities of system

Object Specification

- Most APIs support a limited set of primitives including
  - Points (0D object)
  - Line segments (1D objects)
  - Polygons (2D objects)
  - Some curves and surfaces
    - Quadrics
    - Parametric polynomials
- All are defined through locations in space or *vertices*

Polygon (Triangle) Example



Camera Specification

- Six degrees of freedom
  - Position of center of lens
  - Orientation
- Lens
- Film size
- Orientation of film plane

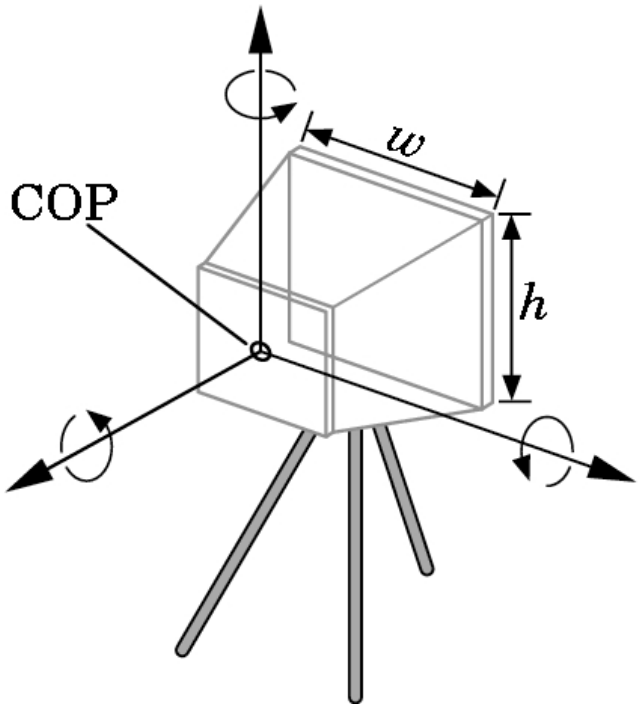


Figure from *Ed Angel, D. Shreiner: Interactive Computer Graphics, 6th Ed., 2012 © Addison Wesley*

Lights & Materials

- Types of lights
  - Point sources vs distributed sources
  - Spot lights
  - Near and far sources
  - Color properties
- Material properties
  - Absorption: color properties
  - Scattering
    - Diffuse
    - Specular

Demo

- Run Tutorial Program