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Models and Architectures

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Objectives

-
- Learn the basic design of a graphics system
 - Introduce pipeline architecture
 - Examine software components for an interactive graphics system



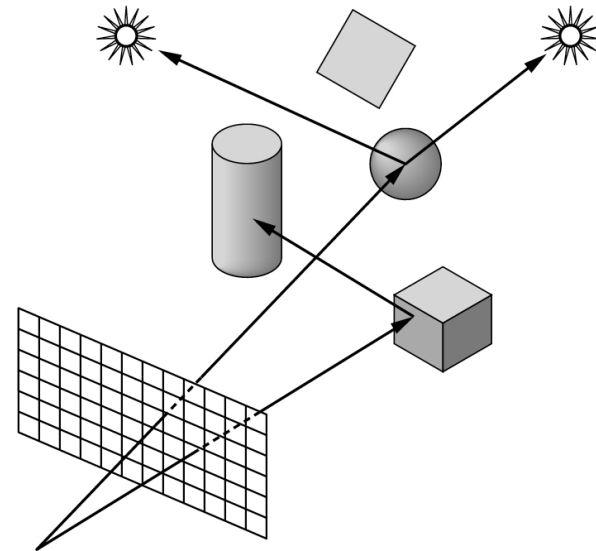
Image Formation Revisited

- Can we mimic the synthetic camera model to design graphics hardware software?
- Application Programmer Interface (API)
 - Need only specify
 - Objects
 - Materials
 - Viewer
 - Lights
- But how is the API implemented?



Physical Approaches

- **Ray tracing:** follow rays of light from center of projection until they either are absorbed by objects or go off to infinity
 - Can handle global effects
 - Multiple reflections
 - Translucent objects
 - Slow
 - Must have whole data base available at all times
- **Radiosity:** Energy based approach
 - Very slow





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Practical Approach

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



application
program

display

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



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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





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





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Primitive Assembly

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

- Line segments
- Polygons
- Curves and surfaces

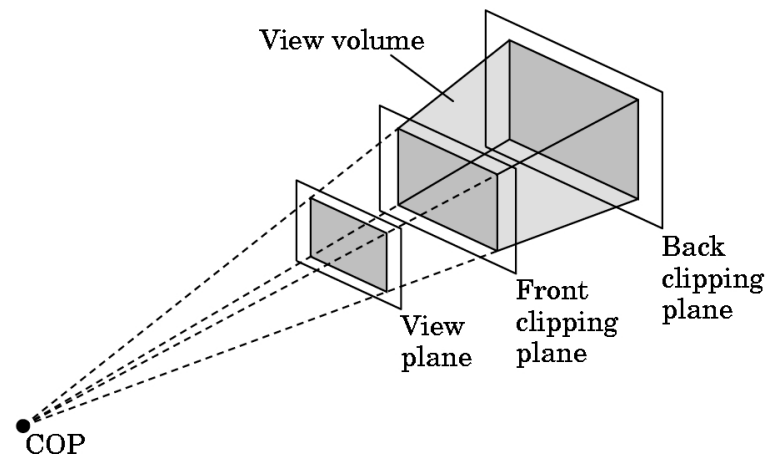
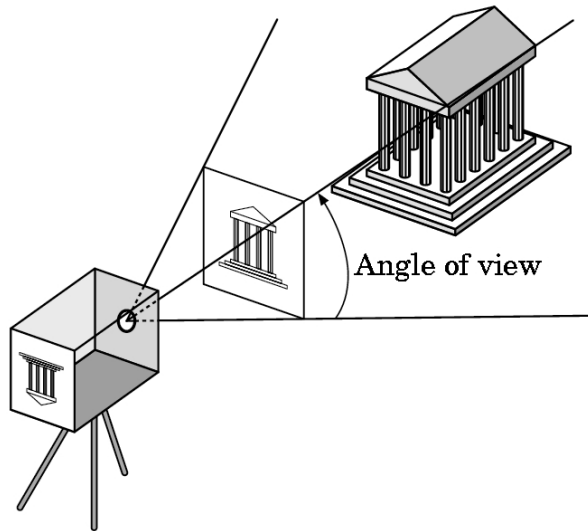




Clipping

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





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 buffer
 - Color and depth attributes
- Vertex attributes are interpolated over objects by the rasterizer





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

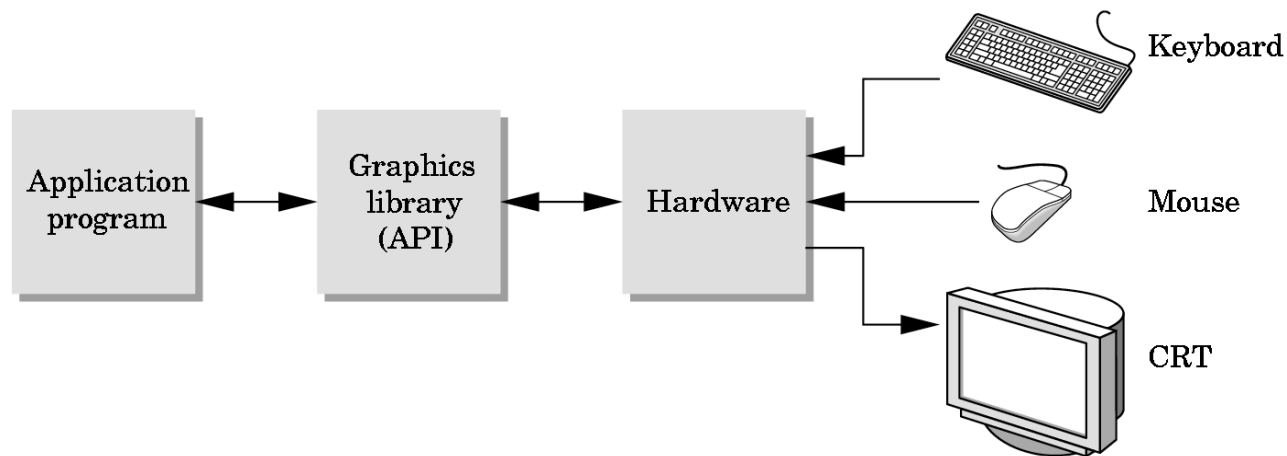




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The Programmer's Interface

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





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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



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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*



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Example

type of object

location of vertex

```
glBegin(GL_POLYGON)
  glVertex3f(0.0, 0.0, 0.0);
  glVertex3f(0.0, 1.0, 0.0);
  glVertex3f(0.0, 0.0, 1.0);
 glEnd();
```

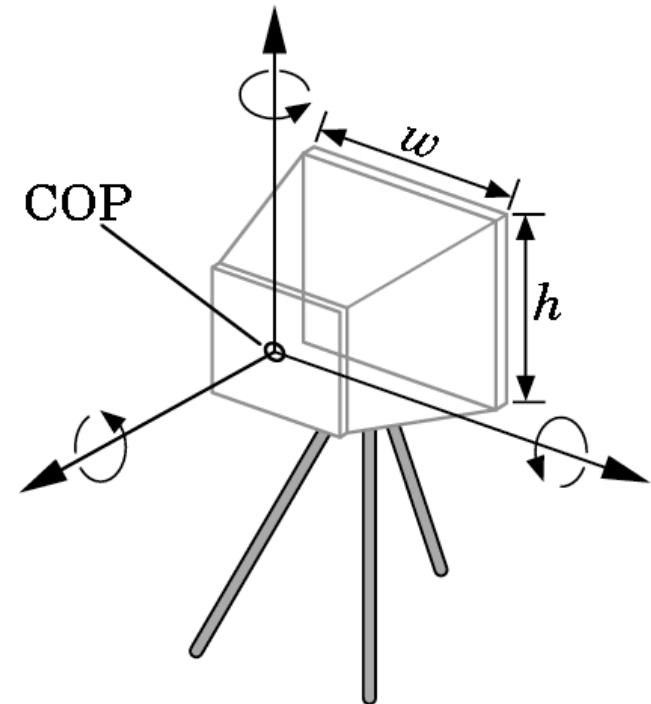
end of object definition



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Camera Specification

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





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Lights and 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