Rendering Pipeline

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Computer Graphics Challenges

- Suppose we can create a precise computer representation of the 3D world
- Questions:
  - How can we generate realistic 2D?
  - What are the best way to model 3D world?
  - How to render such model?

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Rendering

- Synthesizing an image given
  - objects
  - virtual cameras
  - light sources
- Techniques
  - rasterization
  - ray casting

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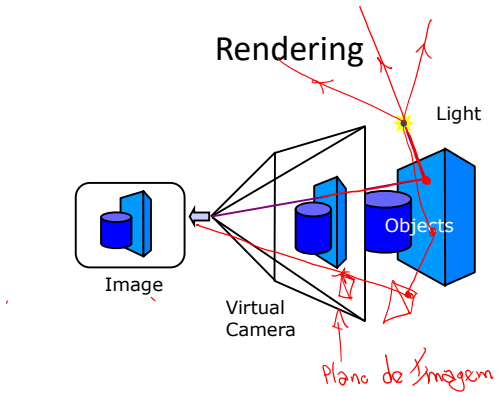
Rendering



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I/O in the rendering pipeline

- Input:
  - Geometric model (normal, color, texture coordinates, pose)
  - Lighting model (direction, position, intensity)
  - Virtual Camera (focal length, pose, etc.)
  - Raster viewport (pixel size, etc.)
- Output:
  - Colors/intesities (image)

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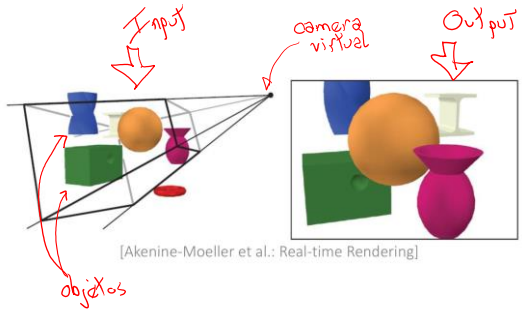
I/O in the rendering pipeline



[Akenine-Moeller et al.: Real-time Rendering]

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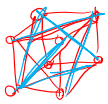
Object representation

- 3D objects can be represented by **primitives** like
  - vertices (i.e., points)
  - lines
  - polygons (e.g., triangles)
- Primitives are processed to generate a 2D image



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Object representation

- List of vertices and attributes
  - X, Y, Z (3D coordinates)
  - R, G, B (color)
  - u, v (texture coordinates)
- Geometric information
  - Positions, normals, curvature
- List of triangles
  - How are the triangles connected (Topological information) ?

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Manifold

- Manifold
  - Every edge has exactly two incident triangles
- Manifold with boundaries
  - Every edge has one or two incident triangles

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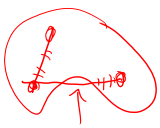
Why do we use triangles?

- Minimal planar primitives
- Piecewise linear representation
- Easy to implement in hardware
- Easy to interpolate attributes
  - Convex Linear Interpolation



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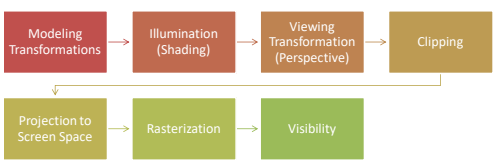
Big picture



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Rendering Pipeline

- Input
  - Soup of 3D triangles
  - Camera and illumination configuration
- Output
  - 2D image
- Each triangle is sent through it in the pipeline

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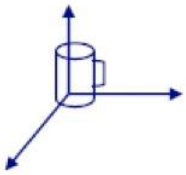
Modeling Transformations

- **Object space**: 3D models defined in their own coordinate system object space
  - Designing objects and not worrying about scene
  - Library of objects



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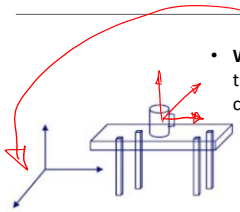
Modeling Transformations



- **World space**: transforms orient the models within a common coordinate frame

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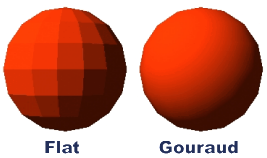
Illumination (Shading)

- Vertices shaded according to material properties, surface properties (normal) and light sources
- Local lighting model
  - Diffuse
  - Ambient
  - Phong



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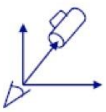
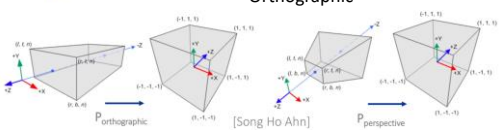
Viewing Transformation



- Project world space to **eye space**
- Projection models
  - Perspective
  - Orthographic



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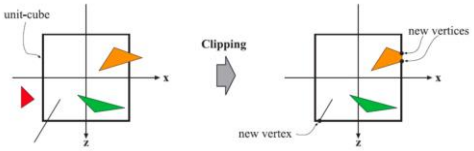
Clipping

- Portions of the object outside the view volume (view frustum) are removed



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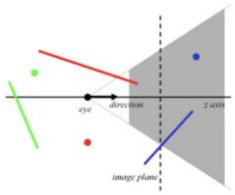
Clipping

- Eliminate portions of objects outside the viewing frustum
- Avoid degeneracies
  - Don't draw stuff behind the eye
  - Avoid division by 0 and overflow
- Efficiency
  - Do not waste time on objects outside the image boundary



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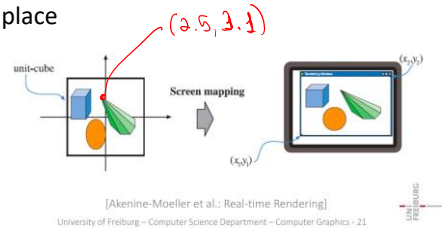
Projection to Screen Space

- The objects are projected to the 2D image place



[Akenine-Moeller et al.: Real-time Rendering]

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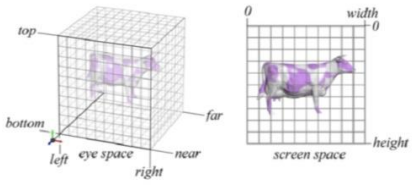
Projection to Screen Space



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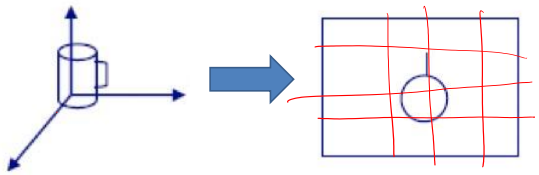
From object space to screen space



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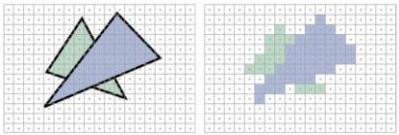
Rasterization

- Scan Conversion
  - Interpolate values (color, depth, etc.) and draw the objects
  - Our primitives are continuous, but the screen is discrete



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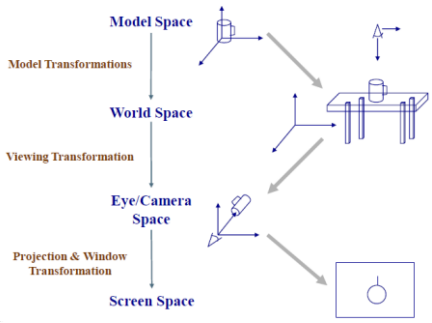
Rendering Pipeline



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