Rendering Pipeline

- Input – 3D Object/Scene Representation
- Output – An image of the input object/scene
- Stages (for POLYGON pipeline)
  - Model view Transformation
  - Projection Transformation
  - Clipping and Vertex Interpolation of Attributes
  - Rasterization and Pixel Interpolation of Attributes
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Model-view Transformation

- Model Transformation
- View Transformation
- World Coordinate System
- Object Coordinate System
World and Object Coordinates

MODEL TRANSFORMATION

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Model Transformation

- Transforming from the object to world coordinates
  - Placing the object in the desired position, scale and orientation

- Can be done by any kind of transformations
  - Graphics hardware/library support only linear transformations like translate, rotate, scale, and shear
View Transformation

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View Transformation

- Position and orientation of eye (9 parameters)
  - View point - POINT: (x, y, z) [3]
  - Normal to the image plane - VECTOR: (vx, vy,vz) [3]
  - View Up - VECTOR: (ux, uy,uz) [3]
  - Default: (0,0,0), (0,0,-1), (0,1,0)

- Transformation to align
  - Eye with the origin
  - Normal to the image plane with negative Z axis
  - View Up vector with positive Y axis
  - Can be achieved by rotation and translation
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Projection Transformation

- Define the “view frustum” (6 parameters)
  - Assume origin is the view point
  - Near and far planes (planes parallel to XY plane in the negative Z axis) [2]
  - Left, right, top, bottom rectangle defined on the near plane [4]
Projection Transformation

- Transforming the view frustum (along with the objects inside it) into a
  - cuboid with unit square faces on the near and far planes
  - the negative Z axis passes through the center of these two faces.
  - Projecting the objects on the near plane

- Consists of a “shear” and a “perspective projection” operations.
Projection Transformation

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Important

- Every vertex undergoes the modelview and projection transformation
- Geometric transformation
  - Topology does not change
- Even when transforming triangles
  - Sufficient to transform the vertices
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Clipping

- Removing the part of the polygon outside the view frustum
- If the polygon spans inside and outside the view frustum
  - introduce new vertices on the boundary
Interpolation of Attributes

- For the new vertices introduced
  - compute all the attributes
  - Using interpolation of the attributes of all the original vertices
Interpolation of Attributes

- For the new vertices introduced
  - compute all the attributes
  - Using interpolation of the attributes of all the original vertices
Window Coordinate Transformation

- Scale XY coordinates of unit cuboid to reflect size of window (relative pixel coordinates).
- Translate these coordinates to the position of the window on the monitor screen to represent the absolute pixel coordinates.
- Z value is used for resolving occlusion.
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Rasterization

- Process of generating pixels in the scan (horizontal) line order (top to bottom, left to right).
  - Which pixels are in the polygon

![Diagram showing scan line and pixels in a polygon]
Interpolation of Attributes

- Interpolate the colors and other attributes at pixels from the attributes of the left and right extent of the scan line on the polygon edge.

- Also in scan line order