CS5182 Computer Graphics Revision

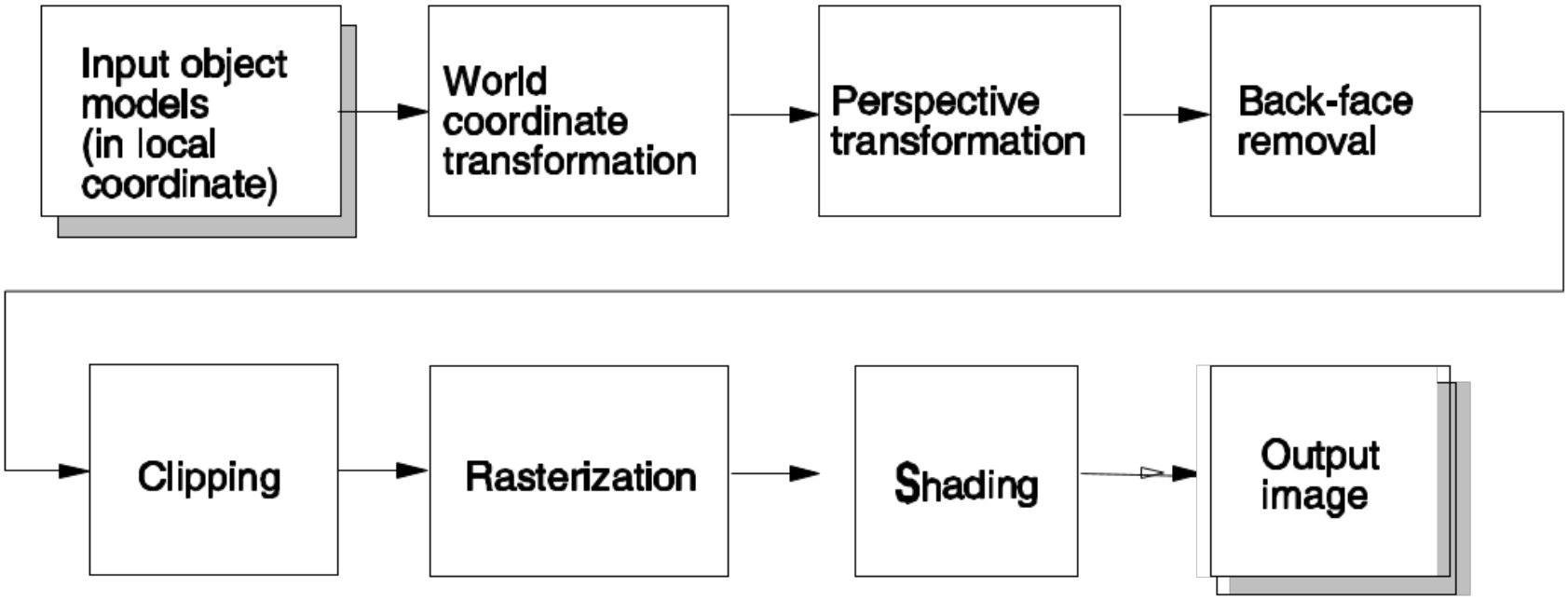
2024/25 Semester A

City University of Hong Kong (DG)

Three Types of Rendering

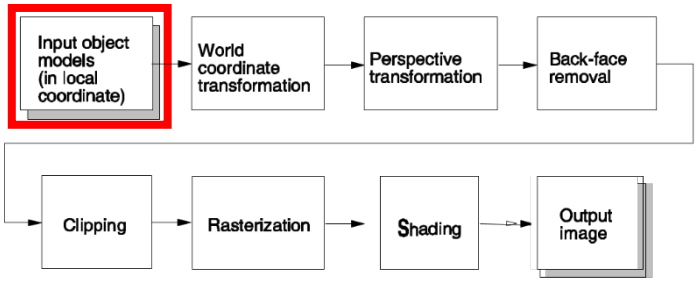
- Rasterization-based rendering pipeline
- Ray tracing and radiosity
- Real-time Rendering

Rasterization based rendering pipeline

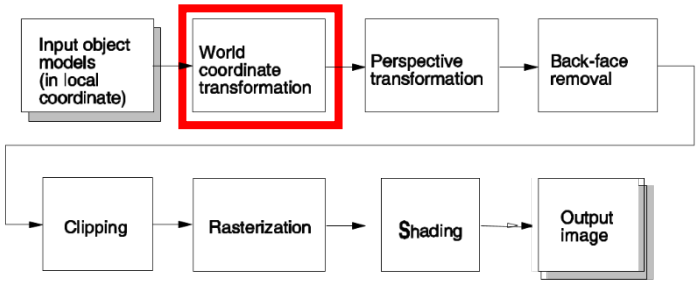


Rasterization-based rendering pipeline

- Object modeling
  - 2D drawing--- a line, a circle
  - Representations of 3D object
    - Point clouds
    - Polygonal meshes (orientable/non-orientable, Euler formula)
    - Subdivision surfaces
    - Implicit surfaces
    - Parametric surfaces
    - Voxel
    - Constructive solid geometry
    - Fractals

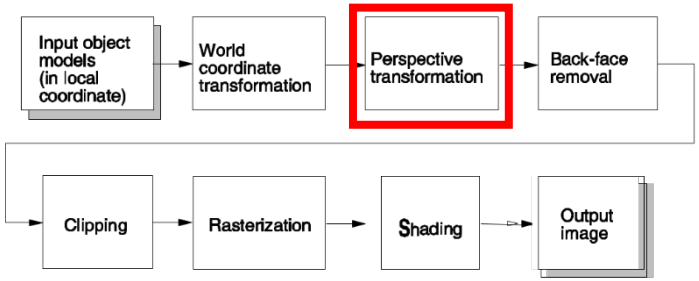


Rasterization-based rendering pipeline



- Transformation
  - Homogeneous coordinates
  - 2D transformations
    - Translation
    - Scaling
      - uniform/non-uniform, simple/general case
    - Rotation
      - rotation orientation, simple/general case, three-step trick
    - Shearing
  - 3D transformations
    - Translation, scaling, rotation around x, y or z-axis
  - Inverse transformation
  - The order of transformations

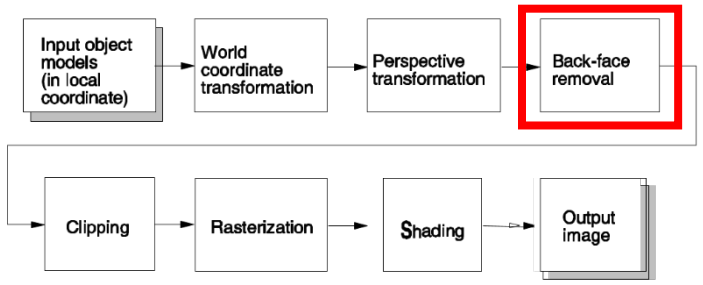
Rasterization-based rendering pipeline



- Projection
  - The elements of projection:
    - COP, projector, projection plane
  - Parallel projection
    - Orthographic projection and the corresponding projection matrix
    - Oblique projection
  - Perspective projection
    - Vanish point
    - One/two/three-point perspective projection
    - Perspective projection matrix
- Perspective transformation
  - After the transformation, the z coordinate keep unchanged
  - Its advantages
  - The transformation matrix

Rasterization-based rendering pipeline

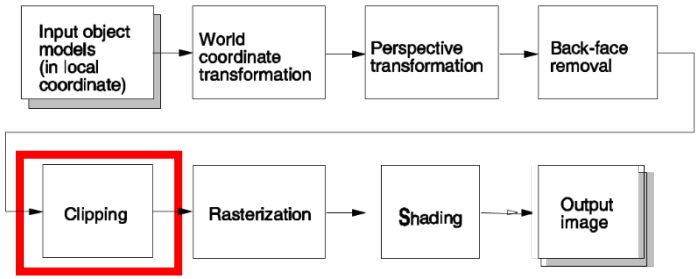
- Hidden/Back Surface Removal
  - Object space algorithms
    - Back-face culling
  - Image space algorithms
    - Depth-sorting (or Painter's) algorithm
    - Z/Depth-buffering algorithm



- After the perspective transformation
  - Using the z component of the normal vector of a typical face

Rasterization-based rendering pipeline

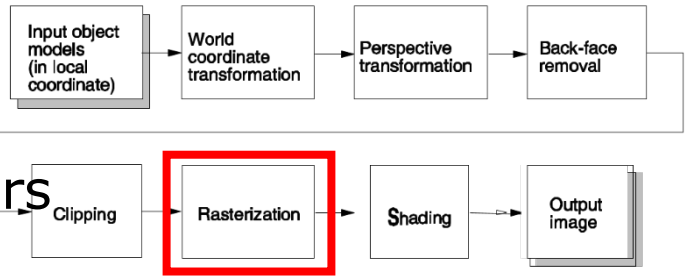
- Clipping
  - The Cohen-Sutherland line-clipping
  - The Sutherland-Hodgman polygon-clipping



- After the perspective transformation
  - The 6 clipping planes become parallel to the three axes, making the clipping easier.

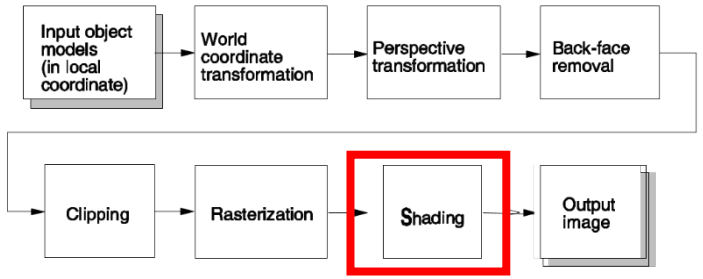
Rasterization-based rendering pipeline

- Rasterization
  - The process of taking a primitive and figuring out which pixels it covers
- Aliasing
  - Spatial aliasing
  - Temporal aliasing
    - Induced by the spatial aliasing
    - Undersampling in the time domain
- Anti-Aliasing
  - Supersampling
  - Accumulation buffer
  - Stochastic sampling
  - Catmull's algorithm
  - The A-buffer method



Rasterization-based rendering pipeline

- Illumination model
  - Light sources
    - Ambient/point/area/spotlight
  - Phong illumination model
    - Ambient reflection
    - diffuse reflection
    - specular reflection
- Shading method
  - Flat shading
  - Smooth shading
    - Gouraud shading
    - Phong shading



Ray Tracing and Radiosity

- Ray Tracing
  - The process
  - How to calculate the color of a pixel
  - The advantages and disadvantages
  - Acceleration
    - Bounding volumes
    - Space subdivision

- Radiosity
  - The process
  - The advantages and disadvantages

Real-Time Rendering

- Progressive rending technique
  - Discrete LoD
  - Progressive mesh
    - Edge collapse
    - Vertex split
  - Selective refinement
- Ways to estimate the visual quality and rendering cost
- Shadows
  - Hard shadows
    - Shadow volume and shadow map
  - Soft shadows

GPU and Animation

- GPU
  - GPU vs. CPU
  - Efficient computation: Data-level parallelism and task-level parallelism
  - Efficient communication
  - GPU architecture
    - Traditional hardware graphics pipeline
    - Advanced hardware graphics pipeline (Programmable vertex processer, rasterizer, programmable fragment processors (which processor performs which tasks?))
- Computer Animation
  - Key frame
  - Procedure
  - Motion capture

Point Cloud Processing

- The irregular structure of point cloud data makes it challenging to design deep neural networks
  - How to conduct convolution
    - How to find neighbors
    - How to aggregate features
  - Several popular feature extraction frameworks
    - Pointnet
    - Pointnet++
    - Dynamic graph cnn

In the final examination, there are **NO** questions for this section.

Final Examination

- There are **SEVEN** questions. **Closed-book**
- Question type
  - Understanding of basic algorithms and operations introduced in the lecture. (~20%)
  - 3 questions about transformation requiring very simple calculations. (~40%)
  - Ray tracing, illumination model, aliasing (~40%)
  - All questions are designed based on the content of the lecture notes and explanations in the lectures.