

Graphics Pipeline for Interactive Rendering

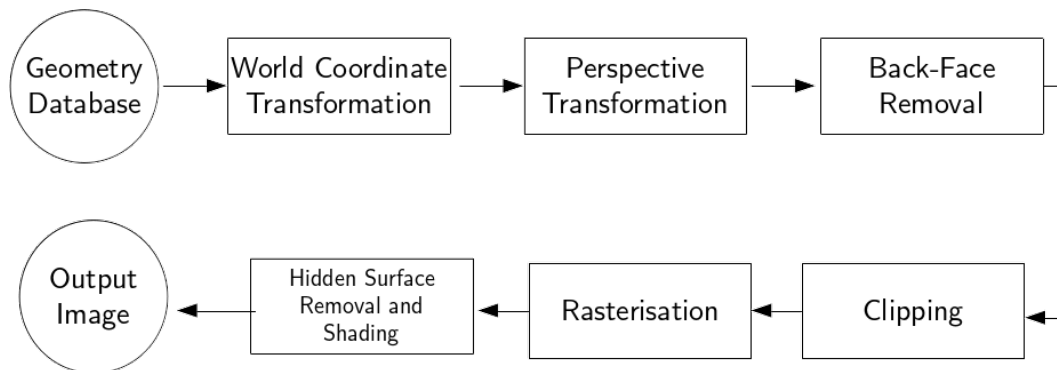
1 Rendering in Computer Graphics

Rendering pipeline comprises of operations converting 3D geometry into a 2D pixel representation for display

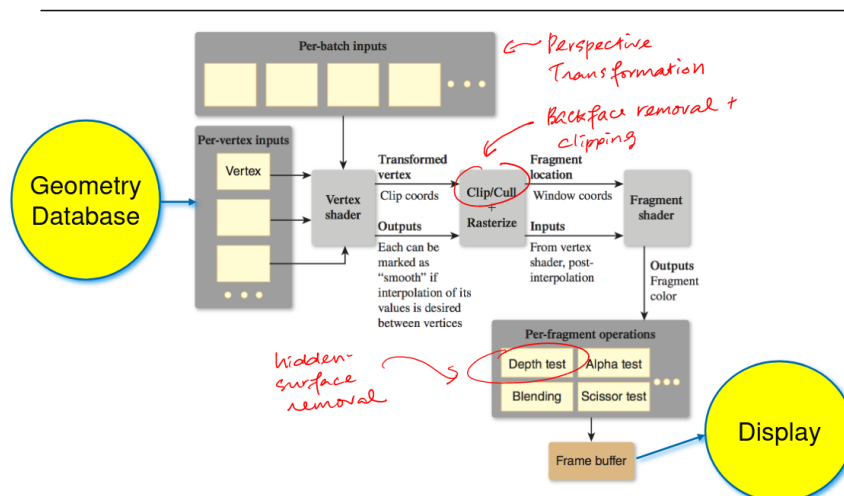
Two types:

- Fixed Function - Use a standard set of operations to efficiently generate pixel representation from 3D polygons based on their visibility
- Programmable - Focus on the flexibility in programming and the utilisation of the parallel processing capability of the GPU

Fixed Function Pipeline



Programmable Rendering Pipeline



2 Local and World Coordinate

- **Geometry Database** - Each object in the scene is first created using a software program in its local coordinate system
- **World coordinate transformation** - Transforms each object to a common world coordinate system

3 Back Face Removal

Remove surfaces of a solid object which are facing away from the viewer. They may contribute to approximately half of the total number of surfacers in a scene

Definition: Front Faces

Object surface facing the viewer

Definition: Back faces

Object surface facing away from the viewer

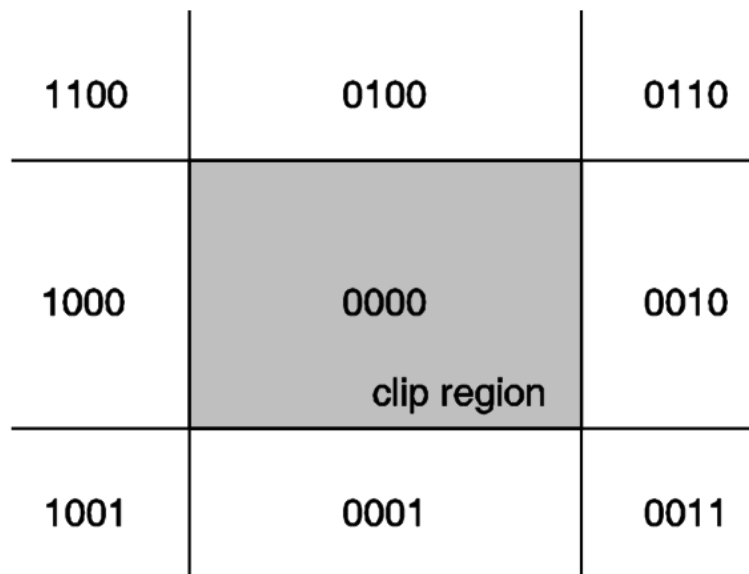
4 Clipping

Clipping is a process to determine the portion of an object lying inside (or outside) a region called the clip region

Definition: Clip region

Typically either a window on a screen or a view volume

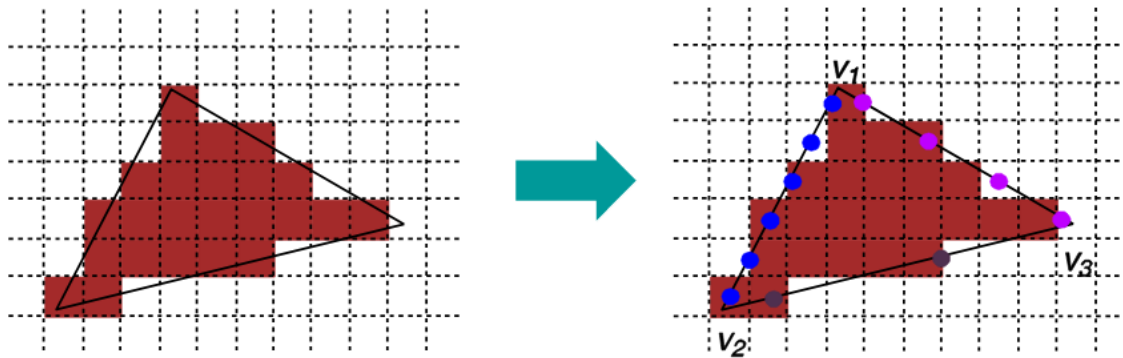
The Cohen-Sutherland Line-Clipping Algorithm works by dividing the area around the clip region as follows



- This allows us to quickly identify lines to be trivially accept/reject
- If both ends of the line are in the clip region then the line can be accepted
- If two of the code words of a line have the same bit set to 1, the line is completely outside and can be rejected
- Otherwise, the line needs to be clipped

5 Rasterization

Break a primitive into pixel fragments



- Consider rasterizing a triangle (v_1, v_2, v_3)
- Interpolate v_1 and v_2 to produce an interpolated point for each row of pixels between v_1 and v_2
- We do the same for v_1 and v_3 as well as v_3 and v_2
- Each pair of interpolated points on a row is called a scanline
- We then interpolate between the pair of interpolated points to form pixel fragments
- Interpolate along the primitive edges followed by the interior pixels between pairs of interpolated points (scanlines)
- Such interpolation is referred to as bilinear interpolation

6 Primitive Drawing on a 2D screen

Painter's algorithm

- Paint distance parts of a scene before parts which are nearer to users, however this can have ambiguity

6.1 Z-Buffering

The most popular hidden surface removal method is the z-buffer method, which is implemented by the majority of existing graphics accelerators

The z-buffer method requires two buffers:

- z-buffer (or depth buffer): determine the nearest primitive fragment at each screen pixel
- image buffer: store the colour value of the nearest primitive fragment at each pixel

Finally, the shading step computes the colour of each visible primitive at each pixel location based on some shading methods

7 Specular lighting

- Bright spot on the object
- Resultant reflection of the incident light concentrates in a local region

Calculation

$$\text{Specular Lighting} = K_s \times I \times \cos^n(\phi)$$

K_s - Specular reflection coefficient

N : surface normal at P

I : light intensity

ϕ : angle between V and R

$\cos^n(\phi)$ - The larger the value of N , the smaller the \cos value

