CS4533 Lecture 8.1 Slides/Notes

Hidden Surface Removal & BSP Trees;
Shadow Projection & Making Decal in HW3
(Notes, Ch 11, Notes)

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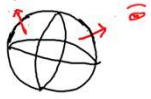
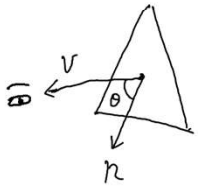
[Below we look at occlusion culling Algorithms.]

1. Back-Face Removal:

Suppose we have closed surface of an obj (eg. sphere, cube, ...), where each polygonal face has a normal vector going outward. eg. 



polygon is facing forward iff $\theta \in [-90^\circ, 90^\circ]$

i.e. $\cos\theta \geq 0$.

i.e. $n \cdot v \geq 0$. $(n \cdot v = |n||v|\cos\theta)$

iff $n \cdot v \geq 0$.

If $(n \cdot v \geq 0)$ render the polygon; otherwise, don't.

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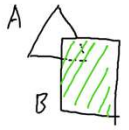
2. Depth Sort and Painter's Algorithm

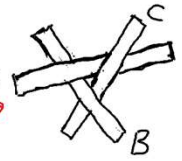
Draw polygons from the farthest to the closest (back to front)



The overlapped portions are over-written.
Only the closest portions are retained.

⇒ We need Depth Sort (sort polygons from the farthest to the closest)

Problem: We may have cyclic ordering. eg.



i.e. Depth order may NOT exist

Partial solution: break into pieces.

Q: How do we break?

A: space-partitioning tree such as BSP tree.

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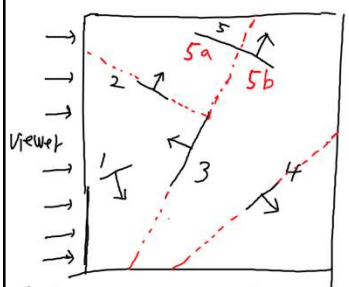
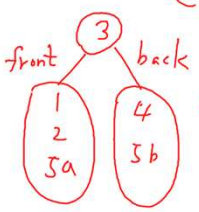
BSP Tree (Binary-Space Partition tree)

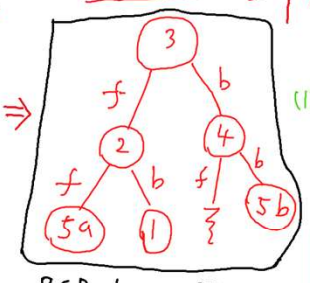
(Render back-to-front)



polygons 1~5 are projected onto the 2D plane as line segments.
↗ indicates the front side.



⇒

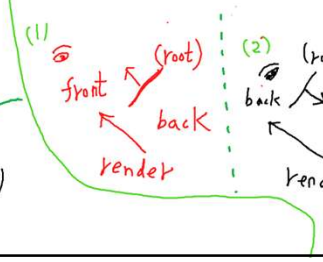


BSP tree T

Using BSP_Render( ) on T:

(A) 4 5b 3 1 2 5a
(B) 4 5b 3 5a 2 1
(C) 5a 2 1 3 4 5b.

Which of (A), (B), (C) is correct?




```
BSP_Render (root)
{
  // Base case for recursion
  If (root == NULL) return;
(1) If (viewer is in front of root)
  {
    BSP_Render (back_child (root));
    display (root);
    BSP_Render (front_child (root));
  }
(2) else // viewer is behind root
  {
    BSP_Render (front_child (root));
    display (root);
    BSP_Render (back_child (root));
  }
}
```

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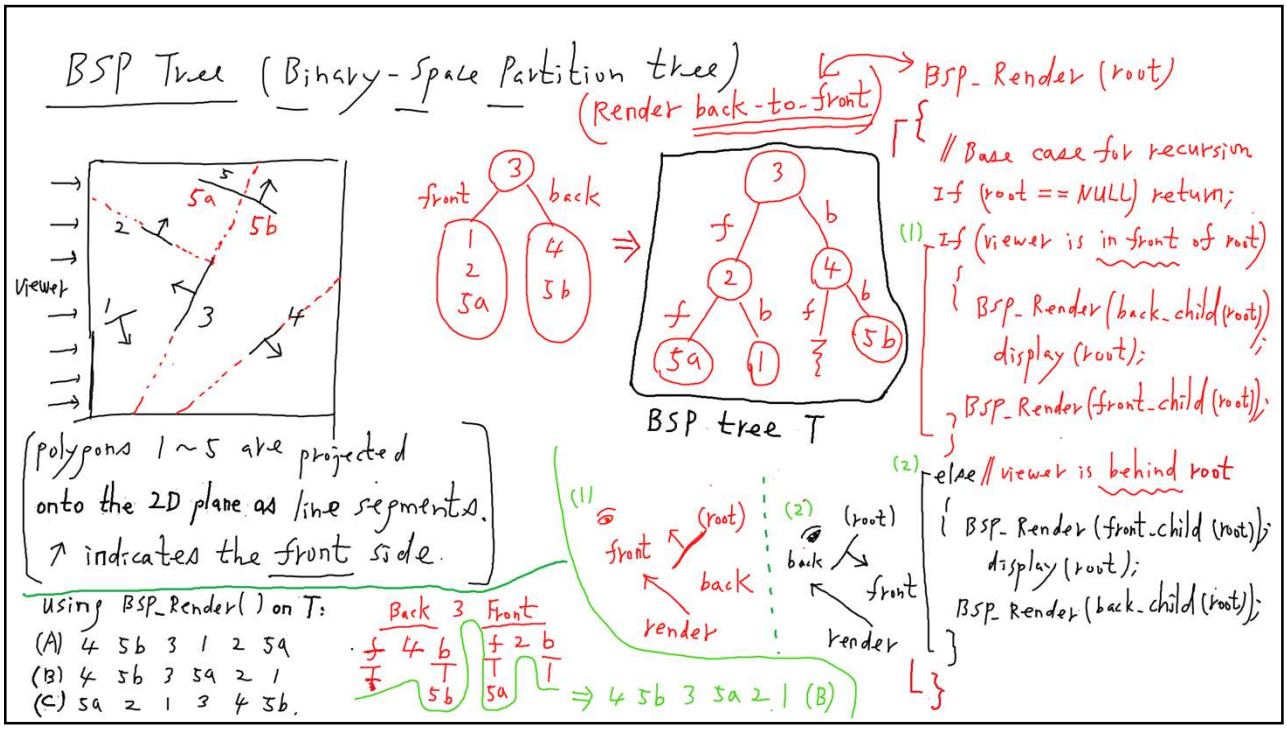
BSP Tree (Binary-Space Partition tree)
(Render back-to-front)
BSP_Render(root)
{
// Base case for recursion
If (root == NULL) return;
(1) If (viewer is in front of root)
{ BSP_Render(back_child(root));
display(root);
BSP_Render(front_child(root));
}
(2) else // viewer is behind root
{ BSP_Render(front_child(root));
display(root);
BSP_Render(back_child(root));
}
}
viewer
5a
5b
front
back
BSP tree T
polygons 1~5 are projected onto the 2D plane as line segments.
↑ indicates the front side.
using BSP_Render() on T:
(A) 4 5b 3 1 2 5a
(B) 4 5b 3 5a 2 1
(C) 5a 2 1 3 4 5b.
Back 3 Front
render
⇒ 4 5b 3 5a 2 1 (B)

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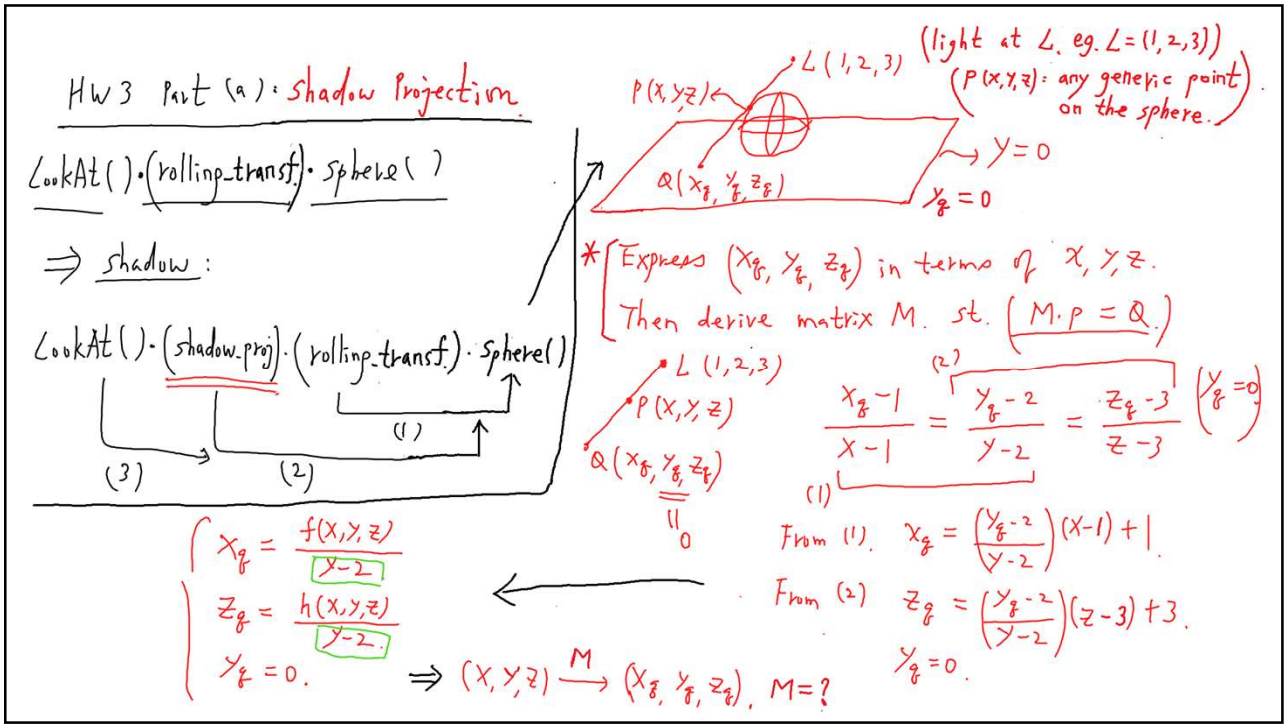
HW3 Part (a): shadow Projection
LookAt() · (rolling_transf) · sphere()
⇒ shadow:
LookAt() · (shadow_proj) · (rolling_transf) · sphere()
(light at L, eg. L=(1,2,3))
(P(x,y,z): any generic point on the sphere.)
L(1,2,3)
P(x,y,z)
Q(xg, yg, zg)
y=0
yg=0
* Express (xg, yg, zg) in terms of x, y, z.
Then derive matrix M. st. (M·P = Q.)
(1)
(2)
(3)
xg = f(x,y,z) / (y-2)
zg = h(x,y,z) / (y-2)
yg = 0.
⇒ (x,y,z) —M→ (xg, yg, zg), M=?
From (1) xg = ((yg-2)/(y-2))(x-1)+1
From (2) zg = ((yg-2)/(y-2))(z-3)+3
yg = 0.

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* Key: Use Homogeneous Coordinate System!

$$Q = \begin{bmatrix} x_q \\ y_q \\ z_q \\ 1 \end{bmatrix} = \begin{bmatrix} f(x,y,z)/(y-2) \\ 0 \\ h(x,y,z)/(y-2) \\ 1 \end{bmatrix} \equiv \begin{bmatrix} f(x,y,z) \\ 0 \\ h(x,y,z) \\ y-2 \end{bmatrix} = \begin{bmatrix} \text{constant entries independent of } x,y,z \\ \\ 4\times 4 \\ M \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix} = P$$

(Perspective Division (P.D.))

Recall: $w \neq 0, w \neq 1$

$$\begin{bmatrix} x \\ y \\ z \\ w \end{bmatrix} \equiv \overset{(P.D.)}{\curvearrowright} \begin{bmatrix} x/w \\ y/w \\ z/w \\ 1 \end{bmatrix}$$

* Note: The 16 entries in the 4×4 matrix M must be constants, independent of x, y, z, so that M can be applied to all different points (with different x, y, z) on the sphere.

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* HW3 Part (b): Making Decal

shadow is the decal on top of the ground.

There are 2 buffers: frame buffer & z-buffer.

we can enable/disable writing to these buffers.

0. Always enable z-buffer testing

⌜1. Disable writing to z-buffer.

Draw ground (only to frame buffer).

NOT to z-buffer.

2. Enable writing to z-buffer.

Draw shadow (to both buffers)

* (ground is NOT in z-buffer to block shadow. So shadow is always drawn on top of ground.)

(Now, we want to put back ground to z-buffer while preserving the current content of frame buffer. ie. draw ground only to z-buffer.)

3. Disable writing to frame buffer.

Draw ground. (only to z-buffer)

4. Enable writing to frame buffer.

⌞ Resume normal ops.

⌜ ⌞ : critical section.

Any other objs should be drawn outside ⌜ ⌞

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