Amey Thakur SE-Comps B-50

Practice Test CG

Class: SE B -50 **Date: 05/05/2020** **Time: 10 AM to 11AM**

Q.1 Explain the Scan line algorithm for visible surface detection.

Q.2 Give different transformation matrices in 3D such as translation, Rotation, Scaling.

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Q.1

Ans.

① A scan line method of hidden surface removal is an another approach of image space method. It is an extension of the scan line algorithm for filling polygon interiors. Here, the algorithm deals with more than one surfaces.

As each scan line is processed, it examines all polygon surfaces intersecting that line determine which are visible.

It then does the depth calculation and finds which polygon is nearest to the view plane.

Finally, it enters the intensity value of the nearest polygon at the position into frame buffer

② Scan line algorithm maintains the edge list in the edge table (ET). The AET (Active Edge Table) contains only edges that cross the current scan line, sorted in order of increasing x.

Scan line are process from left to right

③

ET entry

x	y max	Δx	ID	→

PT entry

ID	Plane eq.	Shading info.	In-out

Scan line method for hidden surface removal

AET Contents

Scan line	Entries			
Scan line 1	AD	BC	EH	FG
Scan line 2	AD	EH	BC	FG

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The active edge list for scan line 1 contains the information for edges AD, BC, EH, FG. For position along the scan line between edges AD and BC, only the flag for surface S_1 is ON. Therefore, no depth calculation are necessary and intensity information for surface S_1 is entered into the frame buffer. Similarly between edges EH and FG, only the flag for surface S_2 is ON and during that portion of scan line intensity information for surface S_2 is entered into frame buffer

4. For scan line 2, The active edge list contains edges AD, EH, BC and FG. Along the scan line 2 from edge AD to edge EH, only the flag for surface S_1 is ON. However, between edges EH and BC, the flags for both surfaces are ON. In the portion of scan line 2, the depth calculations are necessary. Here we assumed that the depth of S_1 is less than the depth of S_2 and hence the intensities of surfaces S_1 are loaded into frame buffer. Then for edge BC to edge FG portion of scan line 2 intensities of surface S_2 are entered into the frame buffer because during that portion only flag for S_2 is ON.

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Q2. Explain 3D Translation, Rotation, Scaling and Reflection with matrix representation

Ans:

① Translation:

A point $P(x, y, z)$ is translated to $P'(x', y', z')$ by translation vector such that

$$x' = x + tx$$
$$y' = y + ty$$
$$z' = z + tz$$

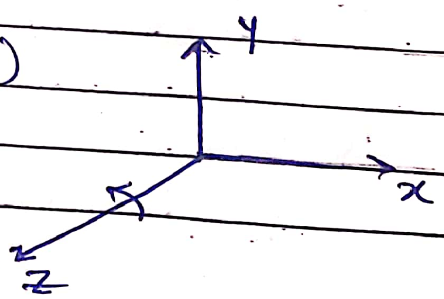
The homogeneous 3D co-ordinate transformation matrix T is given by

$$T = \begin{bmatrix} 1 & 0 & 0 & tx \\ 0 & 1 & 0 & ty \\ 0 & 0 & 1 & tz \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$T^{-1} = \begin{bmatrix} 1 & 0 & 0 & -tx \\ 0 & 1 & 0 & -ty \\ 0 & 0 & 1 & -tz \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

② Rotation: (i) Rotation about Z axis

Rotation about Z axis by an angle θ in anti-clockwise direction will shift point $P(x, y, z)$ to $P'(x', y', z')$



$$x' = x\cos\theta - y\sin\theta$$
$$y' = x\sin\theta + y\cos\theta$$
$$z' = z$$

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The rotation matrix is

$$R_z = \begin{bmatrix} \cos\theta & -\sin\theta & 0 & 0 \\ \sin\theta & \cos\theta & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Inverse rotation i.e. rotation in clockwise direction is obtained by replacing θ by $-\theta$.

The matrix for reverse rotation is

$$R_z^{-1} = \begin{bmatrix} \cos\theta & \sin\theta & 0 & 0 \\ -\sin\theta & \cos\theta & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

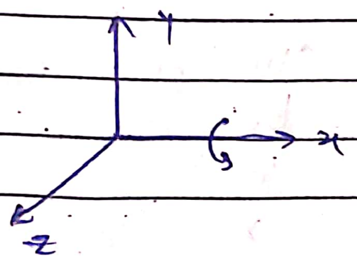
Transformation equation for rotation about x-axis and y-axis can be obtained with cyclic permutation x, y and z.

Replacing $x \rightarrow y \rightarrow z \rightarrow x$

(ii) Rotation about x-axis

Rotation about x axis by an angle θ in anticlockwise direction will shift point $P(x, y, z)$ to $P'(x', y', z')$.

All x-coordinates will remain unchanged



New co-ordinate,

$$y' = y\cos\theta - z\sin\theta$$

$$z' = y\sin\theta + z\cos\theta$$

$$x' = x$$

Matrix representation is

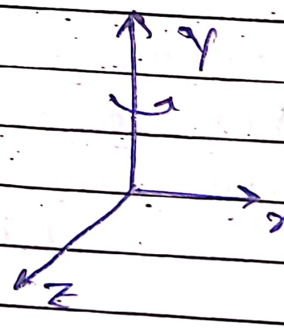
$$R_x = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos\theta & -\sin\theta & 0 \\ 0 & \sin\theta & \cos\theta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Inverse rotation about x-axis. i.e. rotation in clockwise direction is obtained by replacing θ by $-\theta$.

Matrix for inverse rotation is

$$R_x^{-1} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos\theta & \sin\theta & 0 \\ 0 & -\sin\theta & \cos\theta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

(iii) Rotation about Y-axis
Rotation about Y axis by an angle θ in anticlockwise direction will shift point $p(x, y, z)$ to $p'(x', y', z')$



All z coordinates will remain unchanged

The new coordinate will then be

$z' = z\cos\theta - x\sin\theta$

$x' = z\sin\theta + x\cos\theta$

$y' = y$

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Matrix representation for y-axis rotation is

$$R_y = \begin{bmatrix} \cos\theta & 0 & \sin\theta & 0 \\ 0 & 1 & 0 & 0 \\ -\sin\theta & 0 & \cos\theta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Inverse rotation i.e. rotation in clockwise direction

$$R_y^{-1} = \begin{bmatrix} \cos\theta & 0 & -\sin\theta & 0 \\ 0 & 1 & 0 & 0 \\ \sin\theta & 0 & \cos\theta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

3) Scaling :

A point $P(x, y, z)$ is scaled to $P'(x', y', z')$ such that,

$$x' = x \cdot s_x$$
$$y' = y \cdot s_y$$
$$z' = z \cdot s_z$$

The homogeneous 3D coordinate transformation of matrix S is given by

$$S = \begin{bmatrix} S_x & 0 & 0 & 0 \\ 0 & S_y & 0 & 0 \\ 0 & 0 & S_z & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

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(4) Reflection:

3D reflection about x-axis, y-axis and z axis is given by

$$Rf_x = \begin{bmatrix} -1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$Rf_y = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$Rf_z = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$