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TUTORIAL - 6

Ques 1. Explain homogeneous coordinate system.

Ans To perform sequence of transformation such as translation followed by rotation and scalling. To shorten this process we have to use 3 x 3 transformation matrix instead of 2 x 2. To do so we use extra dummy coordinate $\boxed{w}$.

→ We can represent points by 3 members instead of 2

$$(x, y) \rightarrow (x_w, y_w, w)$$

$$x_w = x * w \qquad y_w = y * w$$

$$\left(\frac{x}{w}, \frac{y}{w}\right) \leftarrow (x_w, y_w, w)$$

Translation

$$x' = x + t_x$$

$$y' = y + t_y$$

$$\begin{bmatrix} t_x \\ t_y \end{bmatrix} + \begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} x' \\ y' \end{bmatrix}$$

$$\begin{bmatrix} x' \\ y' \\ h \end{bmatrix} = \begin{bmatrix} 1 & 0 & t_x \\ 0 & 1 & t_y \\ 0 & 0 & h \end{bmatrix} * \begin{bmatrix} x \\ y \\ h \end{bmatrix}$$

Rotation

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

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

anti clockwise

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$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}$$

$$\begin{bmatrix} x' \\ y' \\ h \end{bmatrix} = \begin{bmatrix} \cos\theta & -\sin\theta & 0 \\ \sin\theta & \cos\theta & 0 \\ 0 & 0 & h \end{bmatrix} \begin{bmatrix} x \\ y \\ h \end{bmatrix}$$

Scalling

$x' = x \cdot S_x$

$y' = y \cdot S_y$

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} S_x & 0 \\ 0 & S_y \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}$$

$$\begin{bmatrix} x' \\ y' \\ h \end{bmatrix} = \begin{bmatrix} S_x & 0 & 0 \\ 0 & S_y & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ 1 \end{bmatrix}$$

x shearing

$$\begin{bmatrix} 1 & Sh_x & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

y - shearing

$$\begin{bmatrix} 1 & 0 & 0 \\ Sh_y & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

Reflection

$$\begin{bmatrix} x' \\ y' \\ h \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ 1 \end{bmatrix}$$

origin

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

y axis

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

$y = x$

$$\begin{bmatrix} 0 & 1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

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Ques 2. Translate the polygon with coordinates A(2,5), B(7,10) and C(10,2) by 3 units in x-direction and 4 units in y-direction

Ans A(2,5), B(7,10), C(10,2)

$t_x = 2$, $t_y = 4$

$A' = (2+2, 5+4) = (4, 9)$

$B' = (7+2, 10+4) = (9, 14)$

$C' = (10+2, 2+4) = (12, 6)$

New coordinates are A(4, 9)

B(9, 14)

C(12, 6)

$$\boxed{\begin{aligned} x' &= x + t_x \\ y' &= y + t_y \end{aligned}}$$

Ans 3. Scale the polygon with coordinates A(2, 5), B(7, 10) and C(10, 2) by two units in x direction and two units in y direction

Ans A(2, 5), B(7, 10) C(10, 2)

$d_x = 2$

$d_y = 2$

for scalling

$x' = x . d_x$

$y' = y . d_y$

$A' = (2.2, 5.2) = (4, 10)$

$B' = (7.2, 10.2) = (14, 20)$

$C' = (10.2, 2.2) = (20, 4)$

New coordinates are A (4, 10), B (14, 20) and C (20, 4).

Ans 4. Find transformation matrix for reflection about line $y = x$

A: $\begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}$ matrix req. for trans

A (2, 5), B (7, 10), C (10, 2) → Δ

matrix for given Δ

$$\begin{bmatrix} 2 & 7 & 10 \\ 5 & 10 & 2 \end{bmatrix}$$

to get reflected matrix about line $y = x$:

$$\cancel{\begin{bmatrix} 2 & & 10 \\ 5 & 10 & 2 \end{bmatrix} \times \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}}$$

$$\Rightarrow \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix} \times \begin{bmatrix} 2 & 7 & 10 \\ 5 & 10 & 2 \end{bmatrix}$$

$$\Rightarrow \begin{bmatrix} 5 & 10 & 2 \\ 2 & 7 & 10 \end{bmatrix}$$

∴ Reflected coordinates are

A (5, 2)

B (10, 7)

C (2, 10)

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Ans 5 Define the following terms in computer graphics.

a) Parallel Projection

A parallel projection is a projection of ~~3D~~ object in 3D space onto fixed plane called projection / image plane where rays / line of sight / projection lines are parallel to each other. It can be divided into 2 sub categories depending upon DOP (direction of projection) as orthographic or oblique projections.

b) View plane

The plane in which the object is projected in a parallel ~~or~~ prospective projection is called the view plane.

c) Perspective projection

Its a method of projection in which a 3D object can be represented by projecting points upon a picture plane using straight lines converging at a fixed point representing the eye of the viewer.

d) Shearing :
It is the process of modifying the shape of an object in 2D plane. Its the change in shape of the object. In this sliding of the layers of object occurs. The shear can be in one direction or in 2 directions