VR & AR :-

10/8/22

→ What is computer graphics?

— Display mechanism of a comp

Hardware Software

→ CRT → LCD → Plasma Panel → LED → OLED → TFT (Thin Film Transistor)

→ Visual representations of a computer
  → Modelling (Blueprint)
  → Rendering (Display on screen)
  → Animation (Dynamics of moving objects)
    - Shape, size, colour, orientation

→ What do we do with computers?

① — Document processing.
② — CAD
→ LiDAR creates a 3D diagram of the real world
③ — DNA visualization
④ — Traffic

→ Process of rendering static images / animation (sequence of images) in efficient way. — CG

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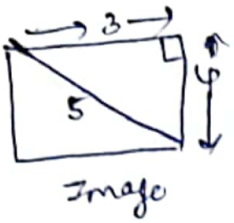
Basic Terms :-

1) Pixel - Smallest unit in image.
2) Resolution - W×H (width × Height)
3) PPI - Pixels per inch

To calculate PPI, we need to know total Pixels



$PPI = \frac{\text{Pixels total}}{\text{Diagonal length}} = \frac{1860 \text{ Pixels}}{5 \text{ inch}}$

$= \frac{\text{---}}{\text{---}}$ Pixels/inch

4) ~~Aspect~~ Aspect ratio $= \frac{W}{H}$ (if $W=H=1$, Square)

5) Frame Buffer = Contains info about the image [kind of memory]

—

We have object which can be divided to discrete levels such as pixels

=

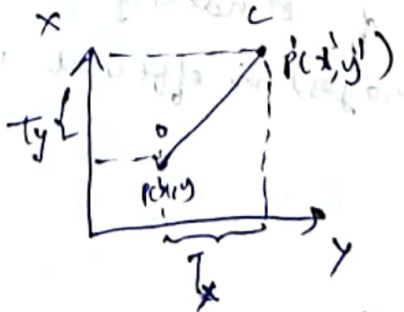
We can perform many transformations on primitives (objects)

Transformations:

① Translation

$P\begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} x \\ y \end{bmatrix}$

$P'\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} x' \\ y' \end{bmatrix}$



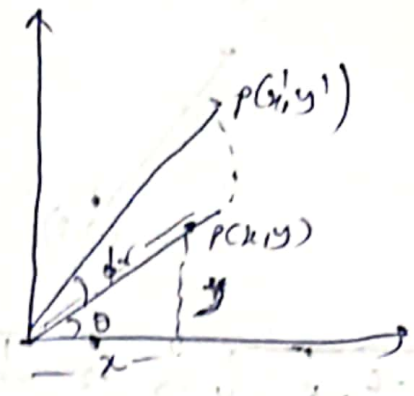
$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} x \\ y \end{bmatrix} + \begin{bmatrix} T_x \\ T_y \end{bmatrix}$ ... $x' = x + T_x$

$y' = y + T_y$

$P' = P + T$

2D - Representation.

Rotation :-



$\cos\theta = \frac{x}{r} \rightarrow x = r\cos\theta$

$\sin\theta = \frac{y}{r} \Rightarrow y = r\sin\theta$.

$\rightarrow x' = r\cos(\theta+\phi)$

$y' = r\sin(\theta+\phi)$

$\rightarrow x' = r[\cos\phi\cos\theta - \sin\theta\sin\phi)$

$y' = r.(\sin\theta\cos\phi + \cos\theta\sin\phi)$

$$\rightarrow \boxed{\begin{aligned} x' &= x\cos\phi - y\sin\phi \\ y' &= y\cos\phi + x\sin\phi \end{aligned}} = x\sin\phi + y\cos\phi$$

$$* \begin{bmatrix} \cos\phi & -\sin\phi \\ \cos\phi & \sin\phi \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} \times$$

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

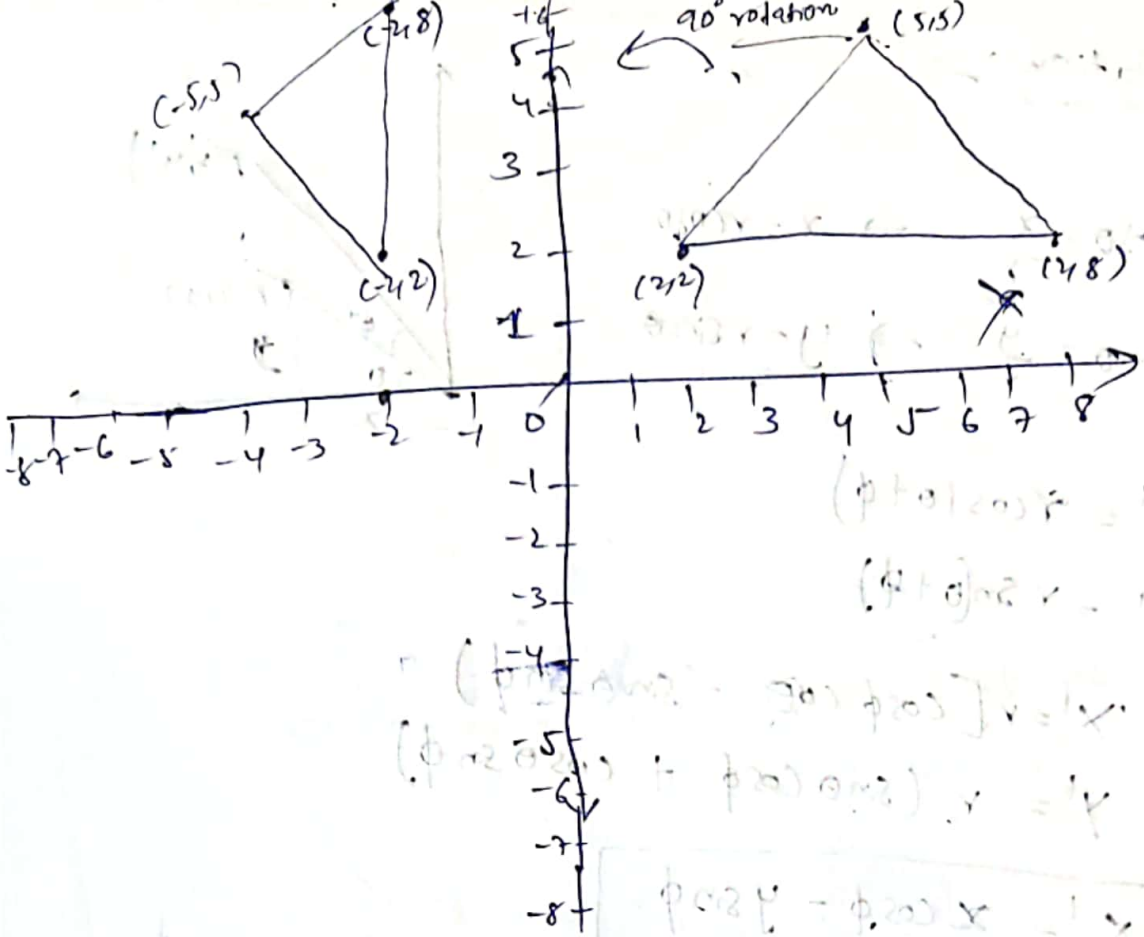
$$P' = R\,P$$

Ex: $a(2,2)$, $b(8,2)$, $c(5,5)$ $\theta = 90^\circ$

$$a' = \begin{bmatrix} 0 & -1 \\ 1 & 0 \end{bmatrix} \begin{bmatrix} 2 \\ 2 \end{bmatrix} = \begin{bmatrix} -2 \\ 2 \end{bmatrix}$$

$$b' = \begin{bmatrix} 0 & -1 \\ 1 & 0 \end{bmatrix} \begin{bmatrix} 8 \\ 2 \end{bmatrix} = \begin{bmatrix} -2 \\ 8 \end{bmatrix}$$

$$c' = \begin{bmatrix} 0 & -1 \\ 1 & 0 \end{bmatrix} \begin{bmatrix} 5 \\ 5 \end{bmatrix} = \begin{bmatrix} -5 \\ 5 \end{bmatrix}$$



To-do ✓

from prev page.

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Scaling ⊢ (Size changes)

$P[x, y] \xrightarrow{S_x, S_y} [x', y']$

$x' = S_x x$

$y' = S_y y$

$\begin{bmatrix} x' \\ y' \end{bmatrix} = S \cdot \begin{bmatrix} x \\ y \end{bmatrix}$

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

$P' = SP$

Aniruddh

→ Reflection
→ Shearing – Shape changes

$x' = x + Sh_x y$

X-axis $= \begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} 1 & Sx \\ 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}$ $y' = y$

Y-axis $= \begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ Sy & 1 \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}$ $x' = x$, $y' = y + Sh_y x$

1) Scaling $\begin{bmatrix} Sx & 0 \\ 0 & Sy \end{bmatrix}$

2) Rotation
[Clock-] $\begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix}$
[Anti-clock] $\begin{bmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{bmatrix}$

Translation
3) $\begin{bmatrix} 1 & 0 \\ 0 & 1 \\ tx & ty \end{bmatrix}$

4) Reflection X-axis $\begin{bmatrix} +1 & 0 \\ 0 & -1 \end{bmatrix}$ → Reflection (Y-axis) $\begin{bmatrix} -1 & 0 \\ 0 & -1 \end{bmatrix}$

5) Shearing(x) $\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} 1 & Shx \\ 0 & 1 \end{bmatrix}$ $x' = x + shx\, y$, $y' = y$

Shearing (y) $\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ shy & 1 \end{bmatrix}$

Reflections on Y-axis reflection $x' = -x$

$y = const$

on X-axis reflection $y' = -y$

$x = const$

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

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

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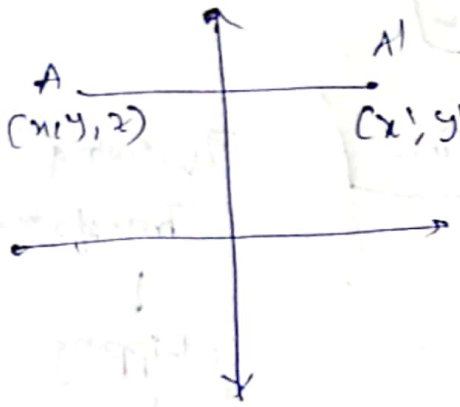
⇒ Project ideas [Must have 3-4 functionalities]

- Virtual classroom
- A small game (3D)
- Solar system
- Entertainment (Virtual Movie Theatre)
- Gesture Management (Drones, Controlling computers)
- Eye Movements ...
- Mixed Reality (VR ≠ AR) ↔ (Directions to drive car)
- Traffic Management.
- Tele-operations (Remote control of a robot)

3-D Transformations:



T_x, T_y, T_z

$x' = x + T_x$

$y' = y + T_y$

$z' = z + T_z$

$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & T_x \\ 0 & 1 & 0 & T_y \\ 0 & 0 & 1 & T_z \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

$4\times1 \quad 4\times4 \quad 4\times1$

$$= \begin{bmatrix} x+T_x \\ y+T_y \\ z+T_b \\ 1 \end{bmatrix}_{4\times1}$$

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Projection:

→ Conversion of n dimensional object to (n-1) dimension

→ Process of converting a 3D → 2D object

→ Also defined as "mapping" / Transforming the object in a 4 project plane / plane (YW)

A = (0, 3, 6) $T_x = 3$

B = (4, 5, 10) $T_y = 2$

C = (3, 4, 8) $T_z = 4$

$x' = x + T_x$

$y' = y + T_y$

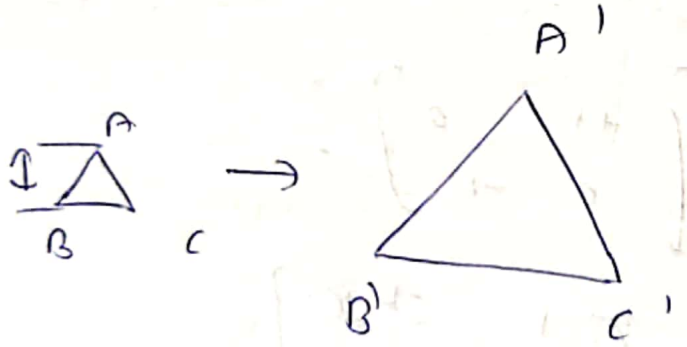
$z' = z + T_z$

A' = (3, 5, 10)

B' = (7, 7, 14)

C' = (6, 6, 12)

Scaling –



Uniform $\{ S_x = S_y = S_z = 1$

Differential $\{ S_x \neq S_y \neq S_z$.

$x' = x * S_x$

$y' = y * S_y$

$z' = z * S_z$

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

A (3, 1, 2)

B (1, 2, 1)

C (0, 1, 1)

$S_x = 2$, $S_y = 1$

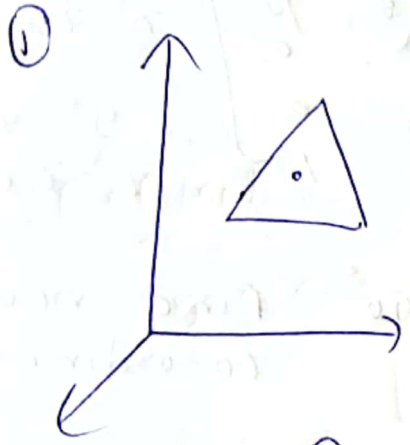
$S_z = 3$.

A' (6, 1, 6)

B' (2, 2, 3)

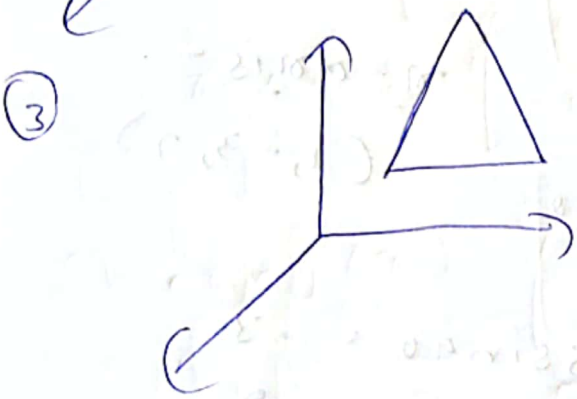
C' (0, 1, 3)

Scaling with respect to point other than origin



Translate point to origin & scale it in a normal way

Translate final points to previous

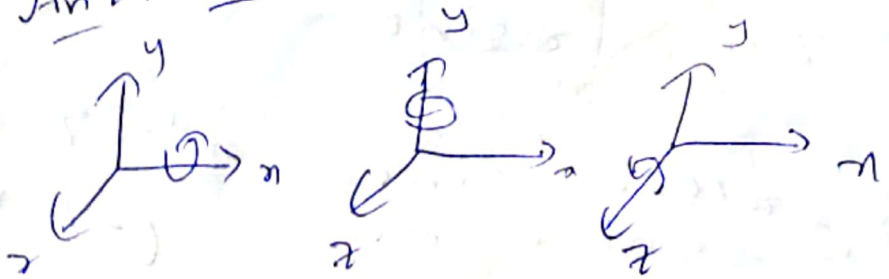


Rotation –

→ Angle of rotation.

→ Axis of rotation.

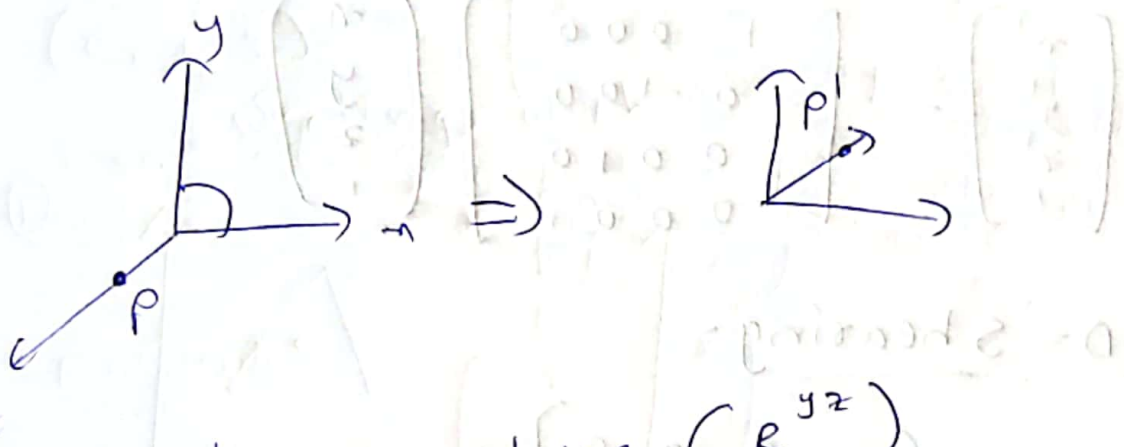
Anti clockwise –



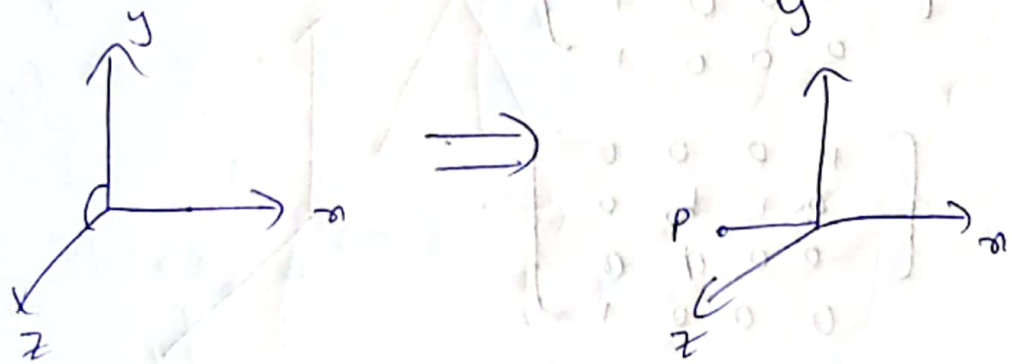
Reflection –

① w.r.t xy plane (R_c^{xy})

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



② w.r.t yz plane (R_c^{yz})



③ ~~w.r.t~~

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

z-axis $\begin{bmatrix} \cos\theta & -\sin\theta & 0 & 0 \\ \sin\theta & \cos\theta & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$

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

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

$z' = z$

x-axis $\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos\theta & -\sin\theta & 0 \\ 0 & \sin\theta & \cos\theta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$

$x' = x$

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

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

y-axis $\begin{bmatrix} \cos\theta & 0 & \sin\theta & 0 \\ 0 & 1 & 0 & 0 \\ -\sin\theta & 0 & \cos\theta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$

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

$y' = y$

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

A(1, 2, 3) Angle Rot^n = 90° Find new co-ordinate.

$x' = x$

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

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

x-axis –

$x' = 1$

$y' = y\cos 90 - 3\sin 90 = -3$

$z' = y\sin 90 + z\cos 90 = 2$

(1, −3, 2)

y-axis –

$x' = z\sin\theta + x\cos\theta = 3$

$y' = y = 2$

$z' = z\cos\theta - x\sin\theta = -1$

(3, 2, −1)

z-axis –

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

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

$z' = z$

(−2, 1, 3)

③ w.r.t xz (R_{ef}^{xz})

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

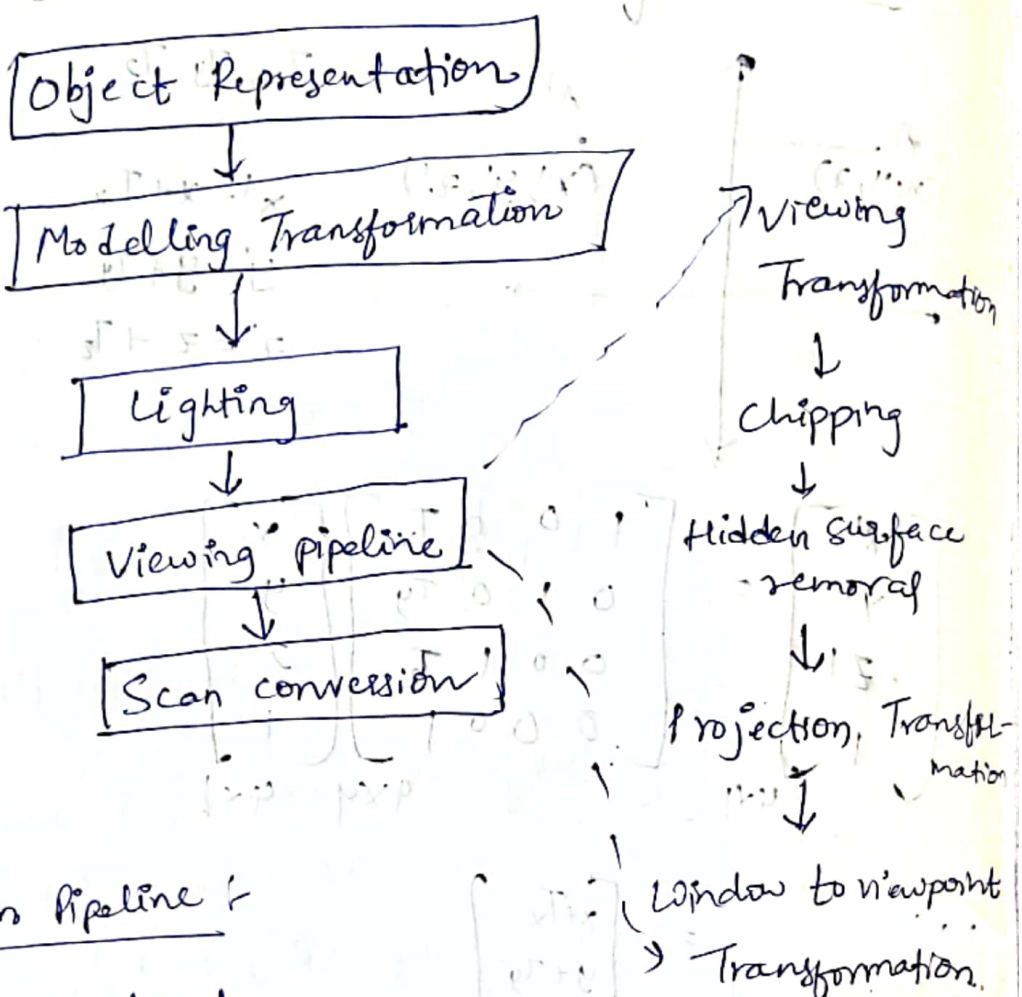
3D - Shearing -

$$Sh^{x} = \begin{bmatrix} 1 & 0 & a & 0 \\ 0 & 0 & b & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$Sh^{y} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ a & 1 & b & 0 \\ 0 & 0 & d & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$Sh^{z} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ a & b & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Graphics pipeline :-

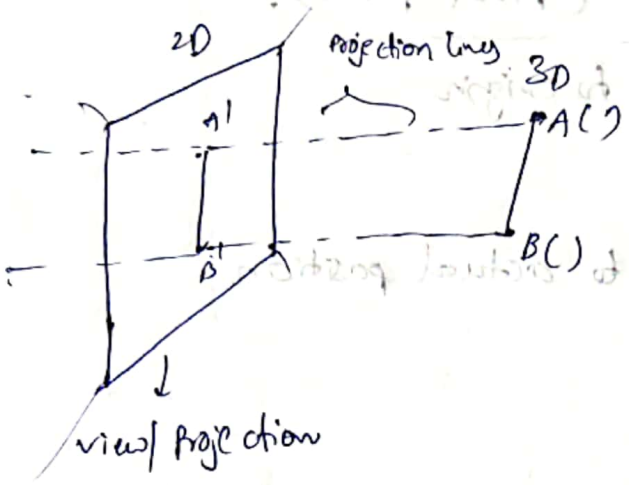


Projection Pipeline :-

Local co-ordinate
↓
Local to world co-ordinate
↓
world coordinate
↓
World to view co-ordinate
↓
3D to 2 view co-ordinate
↓
view to device co-ordinate
↓
device to screen co-ordinate

Types of Projection :

(1) Parallel (2) Perspective



Parallel :

(1) Projection lines are parallel to each other.

(2) After projection, size remains same.

(3) Observer is at infinite distance

Parallel

Orthographic Oblique.

→ Direction of projection ~~not normal~~ is normal to projection plane

Perspective :

(1) Projection lines are not parallel.

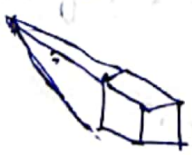
(2) After projection, size varies according to distance between viewer & object

(3) Observer is at finite distance.

Perspective

1-point 2-point 3-point

Viewing point is just single 2-Viewing Points 3-viewing points



faculty $ 11ts

Faculty ..

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"Fixed point" Rotation (Pivot point):

1) Translate point to origin
2) Rotation
3) Translate back to actual position.

6/9/22

VR Goals (Application) :-

1. Learn to build a good VR Experience.
2. Understand how VR works
3. To learn how to criticize VR.
4. Fundamentals to shape the future of VR
   Comfortable & adequate for the task.

Definition of VR.

→ Induced Targeted Behaviour in an "organism" by using "Artificial Sensory" while the organism has little or no "Awareness" of the interface.

Immersion :-

→ We completely involved in the game/reality

→ Presence :-

→ "Open loop" vs "closed loop" :-

→ "Open loop"
↳ Systems where there is no feedback of a moving object

→ Closed loop are systems where there is some kind of positive information is fedback to moving object

→ "Tele presence" :- To create a physical presence from a local/remote presence using multimedia.

→ "Tele operations" operate remotely.

→ AR (Augmented Reality) :-
→ Pokemon go, Snap filters.
→ Placing a organism in real world.

What does VR include :-
→ Watching a movie?
→ Video conferencing?
→ Talking on phone?
→ Playing a video game?
→ Reading a Book?

Amirudh Jak