Leading University

Assignment On

Semester Final Assessment, Spring-20

Course Code: CSE-4113

Course Title: Computer Graphics

Submitted To

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CSE 44th Batch; Section: 10(E+F)

Date of Submission: June 6, 2020

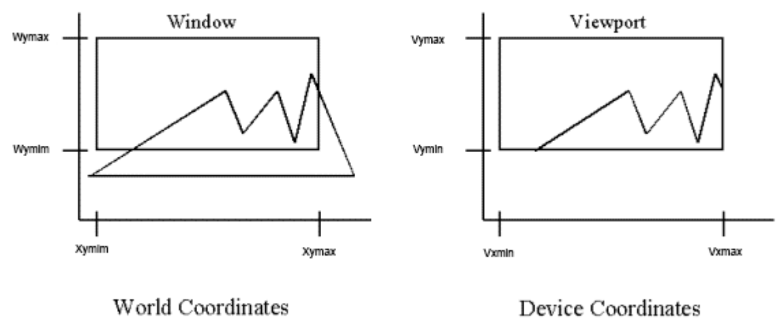
1. What is Window-to-Viewport transformation?

Answer:

Window to Viewport Transformation is the process of transforming the world coordinates (wx_{min}, wx_{max}, wy_{min}, and wy_{max}) of an arbitrary point to its corresponding normalized device coordinates (vx_{min}, $vx_{max,}$ $vy_{min,}$ vy_{max}).

2. Show the mathematical calculation of Window-to-Viewport transformation.

Answer:



(w_x, w_y): A point on Window.

(v_x, v_y): Corresponding point on Viewport

In order to maintain the same relative placement of the point in the viewport as in the window, we require:

For x coordinate,

$$\frac{wx - wx_{min}}{wx_{max} - wx_{min}} = \frac{vx - vx_{min}}{vx_{max} - vx_{min}}$$

For y coordinate,

$$\frac{wy - wy_{min}}{wy_{max} - wy_{min}} = \frac{vy - vy_{min}}{vy_{max} - vy_{min}}$$

Thus,

$$vx = \frac{vx_{max} - vx_{min}}{wx_{max} - wx_{min}} (wx - wx_{min}) + vx_{min}$$

$$vy = \frac{vy_{max} - vy_{min}}{wy_{max} - wy_{min}} (wy - wy_{min}) + vy_{min}$$

Where,

$\frac{vx_{max} - vx_{min}}{wx_{max} - wx_{min}} = Sx;$ is scaling factor of x coordinate and

$\frac{vy_{max} - vy_{min}}{wy_{max} - wy_{min}} =$ Sy ; is scaling factor of y coordinate

3. Write short note on Cohen Sutherland line clipping algorithm.

Answer:

The Cohen–Sutherland algorithm line clipping algorithm is a computer-graphics algorithm used for line clipping. In this algorithm we divide the line clipping process into two phases:

i) identify those lines which intersect the clipping window and so need to be clipped ii) perform the clipping.

All lines fall into one of the following clipping categories.

1. Visible—both endpoints of the line lie within the window.

2. Not visible—the line definitely lies outside the window.

3. Clipping candidate—the line is in neither category 1 nor 2.

4. What are the advantages of Cohen Sutherland line clipping algorithm?

Answer:

Advantages of Cohen Sutherland line clipping algorithm:

i) It calculates end-points very quickly and rejects and accepts lines quickly.

ii) It can clip pictures much large than screen size.

5. Write down the step by step algorithm of Cohen Sutherland algorithm.

Answer:

Step 1: Assign a region code for two endpoints of given line.

Step 2: If both endpoints have a region code 0000

then given line is completely inside.

Step 3: Else, perform the logical AND operation for both region codes.

Step 3.1: If the result is not 0000, then given line is completely outside.

Step 3.2: Else line is partially inside.

Step 3.2.1: Choose an endpoint of the line that is outside the given rectangle.

Step 3.2.2: Find the intersection point of the rectangular boundary (based on region code).

Step 3.2.3: Replace endpoint with the intersection point and update the region code.

Step 3.2.4: Repeat step 2 until we find a clipped line either trivially accepted or trivially rejected.

Step 4: Repeat step 1 for other lines

6. Describe Liang-Barsky line clipping algorithm.

Answer:

The Liang-Barsky algorithm is a line clipping algorithm. This algorithm is more efficient than Cohen–Sutherland line clipping algorithm and can be extended to 3-

Dimensional clipping. This algorithm is considered to be the faster parametric line-clipping algorithm. The following concepts are used in this clipping:

1. The parametric equation of the line.
2. The inequalities describing the range of the clipping window which is used to determine the intersections between the line and the clip window.

The parametric equation of a line can be given by,

X = x1 + t(x2-x1)

Y = y1 + t(y2-y1)

Where, t is between 0 and 1.

7. Write down the step by step algorithm of Liang Barsky algorithm.

Answer:

Step-1. Set tmin=0, tmax=1.

Step-2: Calculate the values of t (t(left), t(right), t(top), t(bottom)),

Step-2.1: If t < tmin ignore that and move to the next edge.

Step-2.2: else separate the t values as entering or exiting values using the inner product.

Step-2.3: If t is entering value, set tmin = t; if t is existing value, set tmax = t.

Step-3: If tmin < tmax, draw a line from (x1 + tmin(x2-x1), y1 + tmin(y2-y1)) to (x1 + tmax(x2-x1), y1 + tmax(y2-y1))

Step-4: If the line crosses over the window, (x1 + tmin(x2-x1), y1 + tmin(y2-y1)) and (x1 + tmax(x2-x1), y1 + tmax(y2-y1)) are the intersection point of line and edge.

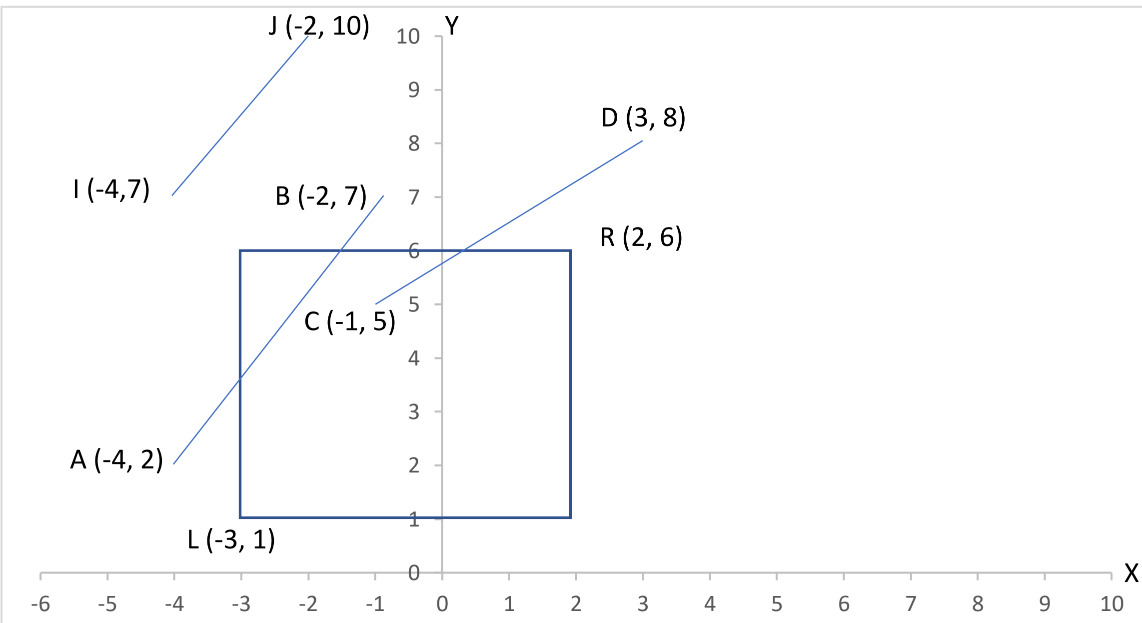
8. Let R be the rectangular window whose lower left-hand corner is at L (-3, 1) and upper right-hand corner is at R (2, 6). Find the region codes and the newer position using Cohen Sutherland for the endpoints –

I. I (-4, 7), J (-2, 10)

II. A (-4, 2), B (-1, 7)

III. C (-1, 5), D (3, 8)

Answer:



Xmin= -3, Xmax=2, ymin=1, ymax=6

The region code for point (x, y) is set according to the scheme

Bit 1 = sign ($y - y_{max}$) = sign (y - 6)

Bit 2 = sign (y_{min}= y) = sign (1 -y)

Bit 3 = sign ($x - X_{max}$) = sign (x - 2)

Bit 4 = sign (x_{min} - x) = sign (-3 - x)

Here

Sign(a) = 1 if a is positive, 0 otherwise

So,

A (-4, 2) = 0001

5 (-1,7) = 1000

C (-1, 7) = 0000

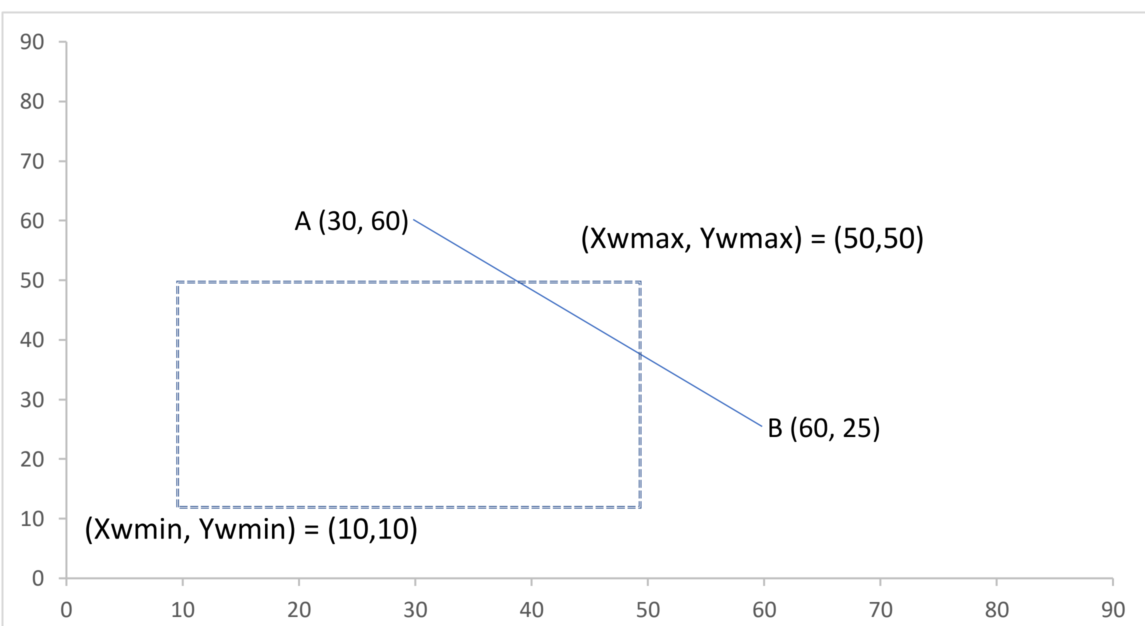
D (3, 8) = 1010

I (-4, 7) = 1001

J (-2, 10) = 1000

9. Apply the Cohen Sutherland line clipping algorithm to clip the line segment with coordinates (30,60) and (60,25) against the window with (Xwmin, Ywmin) = (10,10) and (Xwmax, Ywmax) = (50,50).

Answer:



Clip bit code

After applying AND operation A AND B:

$$\frac{\begin{matrix}1000\\0010\end{matrix}}{0000}$$ (Partially inside) (clipping)

First, find the slop of line AB from the equation:

m = (y2 – y1) / (x2 – x1)

m= (25-60) / (60-30)

=-35/30

=-1.16

Then, we fined the coordinate of intersection point from line AA^-.

The boundary line AA^- is horizontal, so Ymax = y = 50 and calculate x value from this:

x = x1 + (y – y1) / m

= 30+(50-60)/-1.16

=30+(-10)/-1.16

=38.6

the coordinate of intersection point is A^- (38.6,50).

We fined the coordinate of intersection point form line BB^-.

The boundary line BB^- is vertical, so xmax = x =50 and calculate y value from this:

y = y1 + m (x – x1)

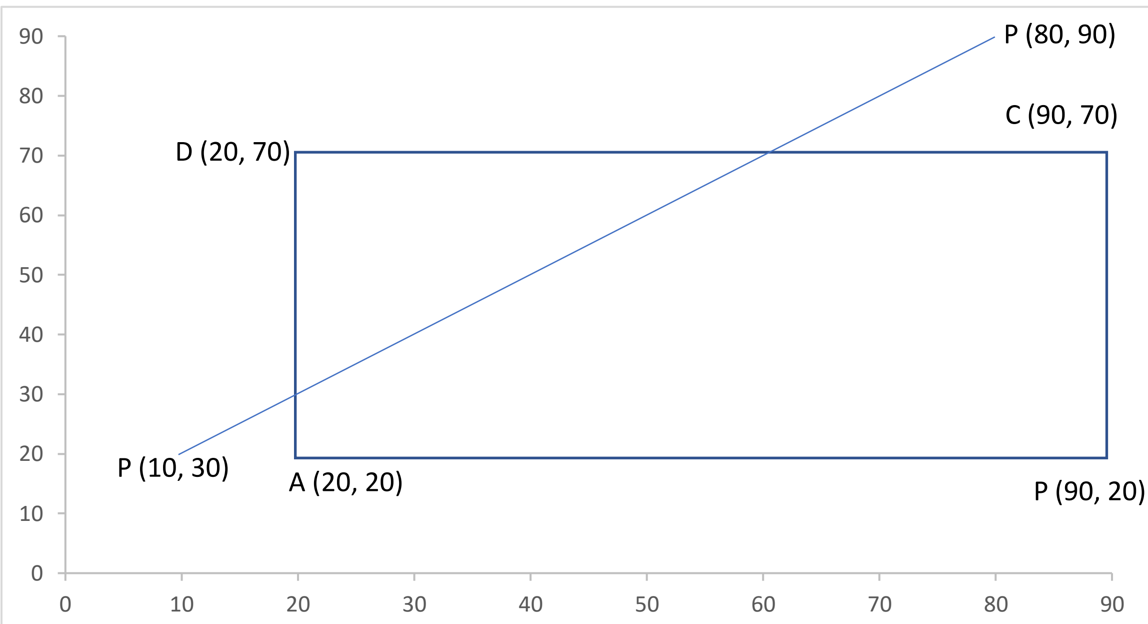
=25+(-1.16) (50-60)

=36.6

The coordinate of intersection point is B^{-} (50,36.6).

10. Let ABCD be the rectangular window with A (20, 20), B (90, 20), C (90, 70) and D (20, 70). Find the region codes for the endpoints and use Cohen Sutherland algorithm to clip the line PQ with P (10, 30) and Q (80, 90).

Answer:



Xmin=20, Xmax=90, ymin=20, ymax=70

Clip bit code

By applying AND operation we get: P AND Q

$$\begin{array}{r} 0001 \\ 1000 \\ \hline 0000 \end{array}$$

(Partially inside) (clipping)

First find the slop of line PQ from the equation:

m = (y2 – y1) / (x2 – x1)

= (90-30) / (80-10)

=60/70

=0.8

Then fined the coordinate of intersection point from line PP-.

The boundary line PP- is vertical, so Xmin=x=20 and calculate y value from this:

y = y1 + m (x – x1)

=30+0.8(20-10)

=30+8=38

the coordinate of intersection points P-(20,38).

Then fined the coordinate of intersection point from line QQ-.

The boundary line QQ- is horizontal, so ymax = y = 70 and find x from this equation:

x = x1 + (y – y1) / m

=80+(70-90)/0.8

=80+(-20)/0.8

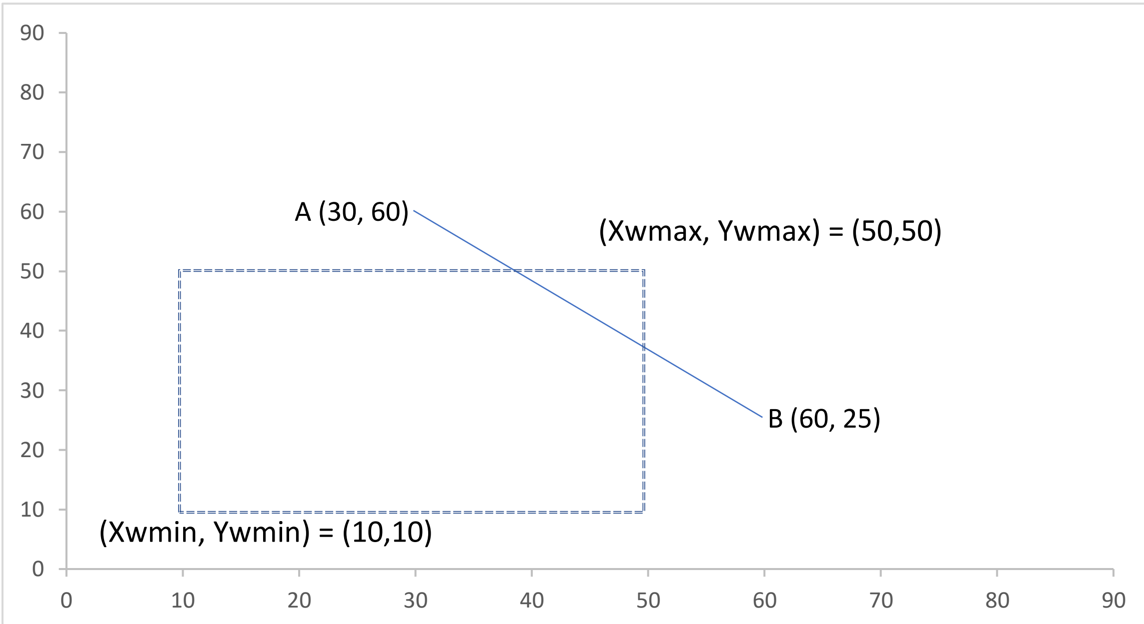
=80+(-25)

= 55

the coordinate of intersection points Q-(55,70).

11. Apply Liang Barsky algorithm to clip the line with coordinates (30, 60) and (60, 25) against the window (Xmin, Ymin) = (10,10) and (Xmax, Ymax) = (50,50).

Answer:



X_{min} =10, X_{max}= 50, Y_{min}= 10, Y_{max}= 50

From parametric equation of a line:

ΔX = 20

ΔY = 6

P1 = -30, P2= 30, P3=35, P4=-35

Q1= 20, Q2=20, Q3=50, Q4=-10

Since,

P_k<0

t1 = MAX (0, 20/30, 10/35)

=MAX (0, -2/3, 2/7)

= 2/7

P_k>0

t2 = MIN (1, 20/30, 50/35)

=MIN (1, 2/3, 10/7)

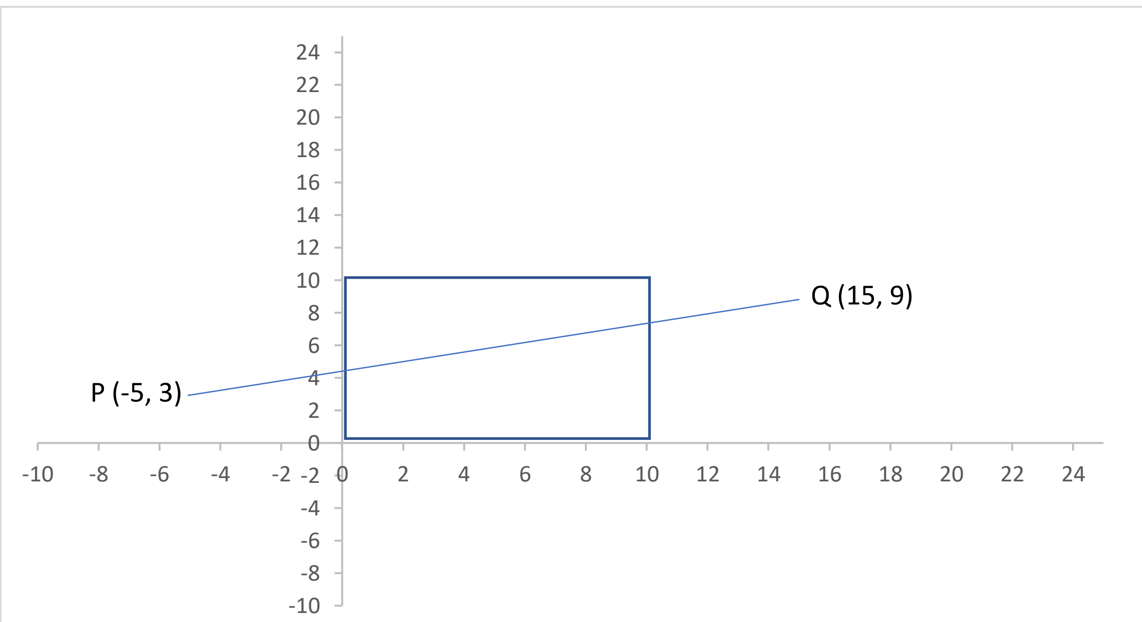
= 2/3

Here, t1>t2

So, there is no line segment to draw.

12. Let R be the rectangular window whose lower left-hand corner is at L (0, 0) and upper right-hand corner is at R (10, 10). Use Liang Barsky algorithm to clip the line PQ with coordinate P (-5, 3) and Q (15, 9).

Answer:



X_{min} =0, X_{max}= 10, Y_{min}= 0, Y_{max}= 10

From parametric equation of a line:

ΔX = 20

ΔY = 6

P1 = -20, P2= 20, P3=-6, P4=6

Q1= -5, Q2=15, Q3=3, Q4= 7

Since,

P_k<0

t1 = MAX (0, 5/20, -3/6)

=MAX (0, 1/4, -3/6)

= 1/4

P_k>0

t2 = MIN (1, 15/20, 7/6)

=MIN (1, 3/4, 7/6)

= 3/4

Here, t1<t2

Finding P,

x= x1 + t*ΔX

=-5 + ¼ * 20

=0

Y= y1+t*Δy

=3+1/4*6

=9/2

P^- (0,9/2)

Finding Q,

x= x1 + t*ΔX

=15 + 3/4 * 20

=30

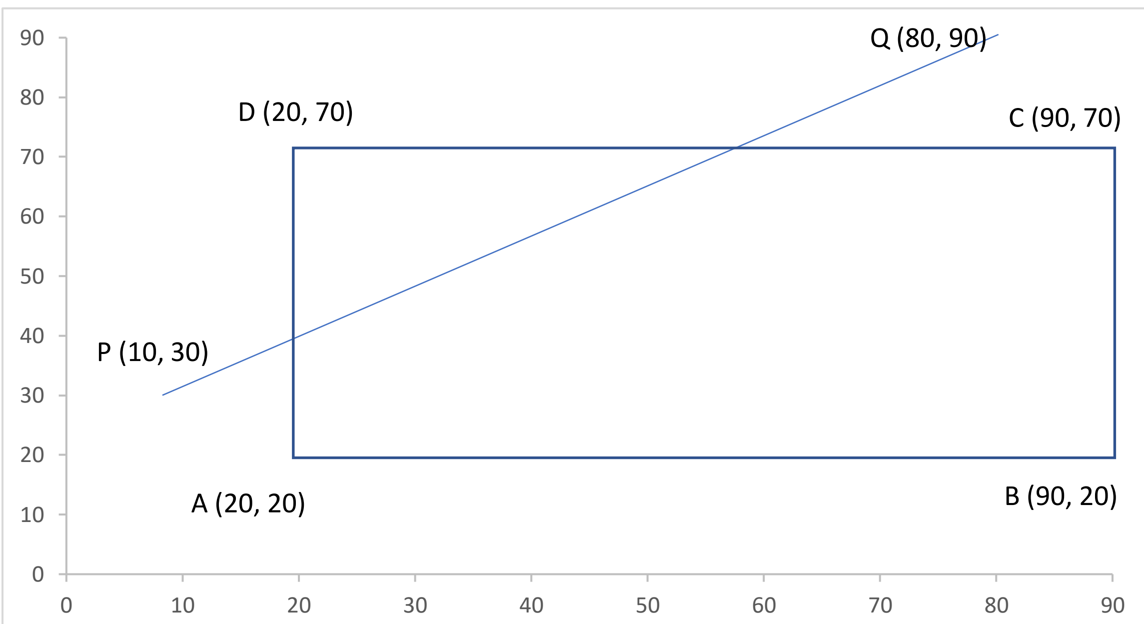
Y= y1+t*Δy

=3+3/4*6

=15/2

Q' (30,15/3)

13. Let ABCD be the rectangular window with A(20, 20), B(90, 20), C(90, 70) and D(20, 70). Use Liang Barsky algorithm to clip the line PQ with P(10, 30) and Q(80, 90).



X_{min} =20, X_{max}= 90, Y_{min}= 20, Y_{max}= 70

From parametric equation of a line:

ΔX = 70

ΔY = 60

$P1 = -70$, $P2= 70$, $P3=-60$, $P4=-60$

$Q1= -10$, $Q2=80$, $Q3=10$, $Q4= 40$

Since,

$P_k<0$

t1 = MAX (0, 10/70, -10/60)

=MAX (0, 1/7, 1/6)

= 1/7

t2 = MIN (1, 80/70, 40/60)

=MIN (1, 8/7, 2/3)

= 2/3

Here, t1<t2

Finding P,

x= x1 + t*ΔX

=10 + 1/7 * 70

=20

Y= y1+t*Δy

=30+1/7*60

=270/7

P^- (20,270/7)

Finding Q,

x= x1 + t*ΔX

=10 + 2/3 * 70

=170/3

Y= y1+t*Δy

=30+2/3*60

=70

Q^- (170/3, 70)

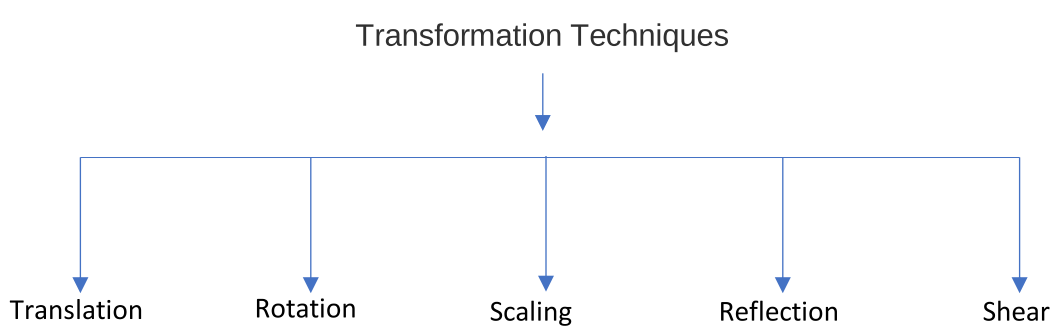
14. What do you mean by 3d Transformation in Computer Graphics?

Answer:

In Computer graphics, Transformation is a process of modifying and re-positioning the existing graphics. When the transformation takes place on a 3D plane, it is called 3D transformation.

15. What are the different techniques of 3d Transformation?

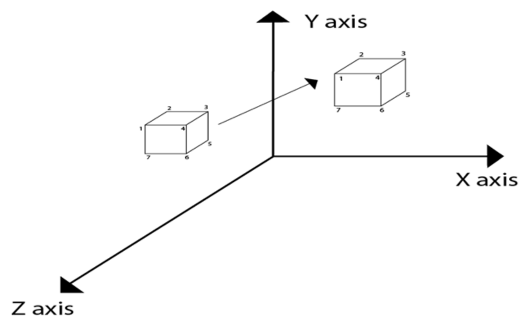
Answer:
In computer graphics, various transformation techniques are-



16.Describe Translation, Rotation, Scaling, Reflection and Shearing with example.

Answer:

Translation:



3D Translation is a process of moving an object from one position to another in a three-dimensional plane. In other word, A translation in space is described by tx, ty and tz. It is easy to see that this matrix realizes the equations:

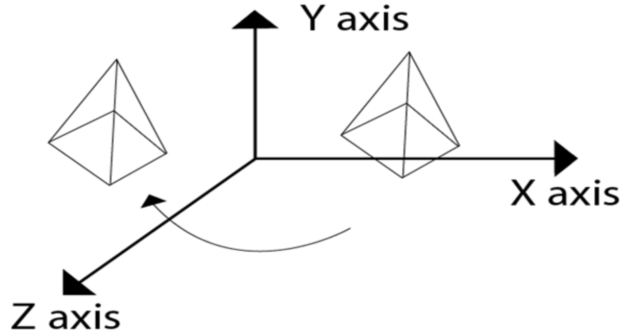
$$\begin{bmatrix} 1 & 0 & 0 & t_X \\ 0 & 1 & 0 & t_Y \\ 0 & 0 & 1 & t_Z \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

x2=x1+tx

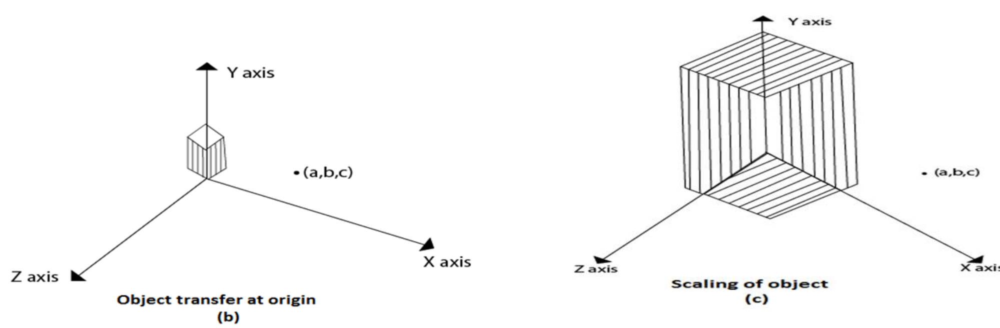
y2=y1+ty

z2=z1+tz

Rotation: 3D Rotation is a process of rotating an object with respect to an angle in a three-dimensional plane. 3D rotation is complex as compared to the 2D rotation. For 2D we describe the angle of rotation, but for a 3D angle of rotation and axis of rotation are required. The axis can be either x or y or z. Following figure show rotation of the object about the Y axis:



Scaling:



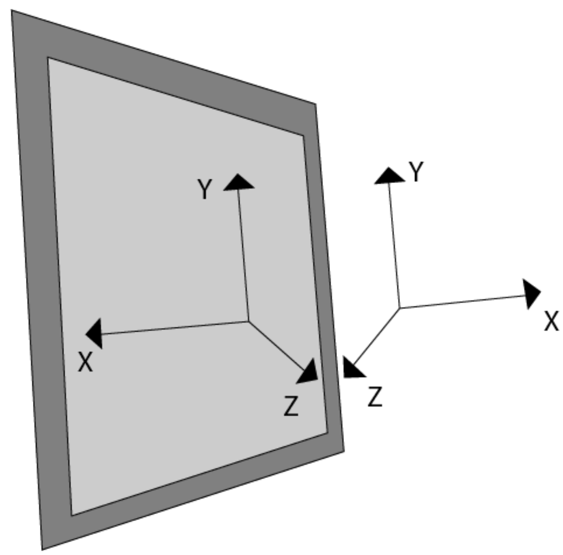
Scaling is a process of modifying or altering the size of objects. The size can be increased or decreased. The scaling three factors are required Sx Sy and Sz.

Sx=Scaling factor in x- direction

Sy=Scaling factor in y-direction

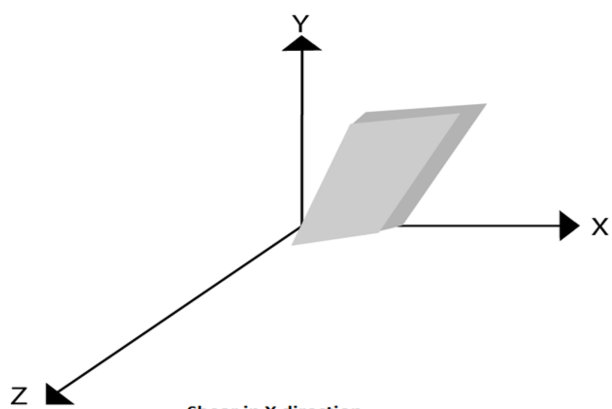
Sz=Scaling factor in z-direction

Reflection: Reflection is a kind of rotation where the angle of rotation is 180 degree. The reflected object is always formed on the other side of mirror. The size of reflected object is same as the size of original object. For reflection, plane is selected (xy,xz or yz).



Reflection relative to XY plane

Shearing: 3D Shearing is an ideal technique to change the shape of an existing object in a three-dimensional plane. Change can be in the x -direction or y -direction or both directions in case of 2D. If shear occurs in both directions, the object will be distorted. But in 3D shear can occur in three directions.



Shear in X direction
(a)

17. Given a 3D object with coordinate point A (1, 3, 5), B (3, 5, 3), C (3, 0, 1), D (2, 1, 5). Apply the translation with the distance 4 towards X-axis, 2 towards Y-axis and 5 towards Z-axis and obtain the new coordinates of the object.

Answer:

Given:

Old coordinates of the object = A (1, 3, 5), B (3, 5, 3), C (3, 0, 1), D (2, 1, 5)

Translation vector = (Tx, Ty, Tz) = (4, 2, 5)

For Coordinates A (1, 3, 5):

Let the new coordinates of A = (Xnew, Ynew, Znew).

Applying the translation equations, we have:

Xnew = Xold + Tx = 1 + 4 = 5

Ynew = Yold + Ty = 3 + 2 = 5

Znew = Zold + Tz = 5 + 5 = 10

Thus, New coordinates of A = (5, 5, 10).

For Coordinates B (3, 5, 3):

Let the new coordinates of B = (Xnew, Ynew, Znew).

Applying the translation equations, we have:

Xnew = Xold + Tx = 3 + 4 = 7

Ynew = Yold + Ty = 5 + 2 = 7

Znew = Zold + Tz = 3 + 5 = 8

Thus, New coordinates of B = (7, 7, 8).

For Coordinates C (3, 0, 1):

Let the new coordinates of C = (Xnew, Ynew, Znew).

Applying the translation equations, we have-

Xnew = Xold + Tx = 3 + 4 = 7

Ynew = Yold + Ty = 0 + 2 = 2

Znew = Zold + Tz = 1+ 5 = 6

Thus, New coordinates of C = (7, 2, 6).

For Coordinates D (2, 1, 5):

Let the new coordinates of D = (Xnew, Ynew, Znew).

Applying the translation equations, we have:

Xnew = Xold + Tx = 2 + 4 = 6

Ynew = Yold + Ty = 1 + 2 = 3

Znew = Zold + Tz = 5+ 5 = 10

Thus, New coordinates of D = (6, 3, 10).

Thus, New coordinates of the object = A (5, 5, 10), B (7, 7, 8), C (7, 2, 6), D (6, 3, 10).

18. Given a homogeneous point (3, 2, 5). Apply rotation 45 degree towards X, Y and Z axis and find out the new coordinate points.

Answer:

Given:

Old coordinates = (Xold, Yold, Zold) = (3, 2, 5)

Rotation angle = θ = 45º

For X-Axis Rotation:

Let the new coordinates after rotation = (X_{new}, Y_{new}, Z_{new}).

Applying the rotation equations, we have-

$X_{new} = X_{old} = 3$

$Y_{new} = Y_{old} \times \cos\theta - Z_{old} \times \sin\theta = 2 \times \cos 45° - 5 \times \sin 45° = -3$

$Z_{new} = Y_{old} \times \sin\theta + Z_{old} \times \cos\theta = 2 \times \sin 45° + 5 \times \cos 45° = 4$

Thus, New coordinates after rotation = (3, -3, 4).

For Y-Axis Rotation:

Let the new coordinates after rotation = (X_{new}, Y_{new}, Z_{new}).

Applying the rotation equations, we have-

$X_{new} = Z_{old} \times \sin\theta + X_{old} \times \cos\theta = 5 \times \sin 45° + 3 \times \cos 45° = 5$

$Y_{new} = Y_{old} = 2$

$Z_{new} = Y_{old} \times \cos\theta - X_{old} \times \sin\theta = 2 \times \cos 45° - 3 \times \sin 45° = 2 \times 0 - 1 \times 1 = -1$

Thus, New coordinates after rotation = (5, 2, -1).

For Z-Axis Rotation:

Let the new coordinates after rotation = (X_{new}, Y_{new}, Z_{new}).

Applying the rotation equations, we have-

Xnew = Xold x cosθ – Yold x sinθ = 3 x cos45° – 2 x sin45° = 0

Ynew = Xold x sinθ + Yold x cosθ = 3 x sin45° + 2 x cos45° = 3

Znew = Zold = 5

Thus, New coordinates after rotation = (0, 3, 5).

19. Given a 3D object with coordinate point A (1, 3, 5), B (3, 5, 3), C (3, 0, 1), D (2, 1, 5). Apply the scaling parameter 4 towards X-axis, 2 towards Y-axis and 5 towards Z-axis and obtain the new coordinates of the object.

Answer:

Old coordinates of the object = A (1, 3, 5), B (3, 5, 3), C (3, 0, 1), D (2, 1, 5)

Scaling factor along X axis = 4

Scaling factor along Y axis = 2

Scaling factor along Z axis = 5

For Coordinates A (1, 3, 5):

Let the new coordinates of A after scaling= (Xnew, Ynew, Znew).

Applying the scaling equations, we have:

Xnew = Xold * Sx = 1 * 4 = 4

Ynew = Yold * Sy = 3 * 2 = 6

Znew = Zold * Sz = 5 * 5 = 25

Thus, New coordinates of A = (4, 6, 25).

For Coordinates B (3, 5, 3):

Let the new coordinates of B after scaling= (Xnew, Ynew, Znew).

Applying the scaling equations, we have:

Xnew = Xold * Sx = 3 * 4 = 12

Ynew = Yold * Sy = 5 * 2 = 10

Znew = Zold * Sz = 3 * 5 = 15

Thus, New coordinates of B = (12, 10, 15).

For Coordinates C (3, 0, 1):

Let the new coordinates of C after scaling = (Xnew, Ynew, Znew).

Applying the scaling equations, we have-

Xnew = Xold * Sx = 3 * 4 = 12

Ynew = Yold * Sy = 0 * 2 = 0

Znew = Zold * Sz = 1 * 5 = 5

Thus, New coordinates of C = (12, 0, 5).

For Coordinates D (2, 1, 5):

Let the new coordinates of D after scaling = (Xnew, Ynew, Znew).

Applying the scaling equations, we have:

Xnew = Xold * Sx = 2 * 4 = 8

Ynew = Yold * Sy = 1 * 2 = 2

Znew = Zold * Sz = 5 * 5 = 25

Thus, New coordinates of D = (8, 2, 25).

Thus, New coordinates of the object = A (4, 6, 25), B (12, 10, 15), C (12, 0, 5), D (8, 2, 25).

20. Given a 3D triangle with coordinate points A(3, 5, 2), B(4, 2, 7), C(5, 6, 4). Apply the reflection on the XY and XZ plane and also find out the new coordinates of the object.

Answer:

Old corner coordinates of the triangle = A (3, 5, 2), B (4, 2, 7), C (5, 6, 4) reflection has to be taken on the XY and XZ plane

For Coordinates A (3,5,2):

Let the new coordinates of A after reflection = (Xnew, Ynew, Znew).

Applying the reflection equations, we have:

Xnew = Xold = 3	Xnew = Xold = 3
Ynew = Yold =5	Ynew = Yold = -5
Znew = Zold =-2	Znew = Zold = 2

New coordinates of A on XY and XZ plane (3,5, -2) and (3, -5, 2)

For Coordinates B (3,5,2):

Let the new coordinates of B after reflection = (Xnew, Ynew, Znew).

Applying the reflection equations, we have:

Xnew = Xold = 4	Xnew = Xold = 4

Ynew = Yold = 2 Ynew = Yold = -2

Znew = Zold = -7 Znew = Zold = 7

New coordinates of B on XY and XZ plane (4, 2, -7) and (4, -2, 7)

For Coordinates C (3,5,2):

Let the new coordinates of C after reflection = (Xnew, Ynew, Znew).

Applying the reflection equations, we have:

Xnew = Xold = 5 Xnew = Xold = 5

Ynew = Yold = 6 Ynew = Yold = -6

Znew = Zold = -4 Znew = Zold = 4

New coordinates of B on XY and XZ plane (5, 6, -4) and (5, -6,4)