COMPUTER GRAPHICS
THIRD CLASS

University of Diyala/ College of education for pure science / Computer science department

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Normalized Device Coordinates:

We need to use a device independent coordinate system called (NDC) to describe the viewport. This device (NDC) better than using the coordinate of the display screen to describe the viewport.

The (NDC) system allows the application programmer to write graphics programs independent of the resolution of the display screen.

World coordinate system: is a user defined coordinate system chosen for a specific application. These screen independent coordinate can have a large or small numeric range, negative values and fraction.

Windowing: Is the capability of displaying part of the Word Coordinate System image, enclosed in a rectangular region. That is when the image described in the world coordinate system is too complicated to be viewed clearly on the screen and the user may want to view (and enlarge) only a portion of the image. Adjusting the size of the window has the effect of enlarging or shrinking or even distorting a portion of the image or the entire image.

Viewport: it is a rectangular region of the screen where the contents of the window are displayed. That is done when we want to display different views of the image in different regions of the screen. Using the same window and several viewport, the same object can be placed in different regions.

Window To Viewport mapping: It is a transformation function that converts from Word coordinate system to (NDC). It produces on specific view of the image.
To change the view we must change the window and/or the viewport and reinvoke this mapping. The window and the viewport are described by the coordinates of the lower left vertex.

Window to viewport mapping algorithm: We take the coordinates of the points of the object in a designated window and transform them to give the coordinates of the corresponding points in the viewport on the screen As shown below.

World Coordinates   Device Coordinates
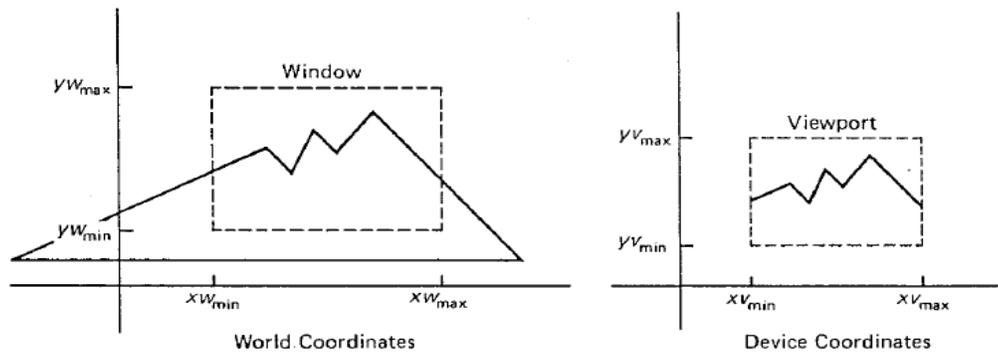
This mapping require three steps:
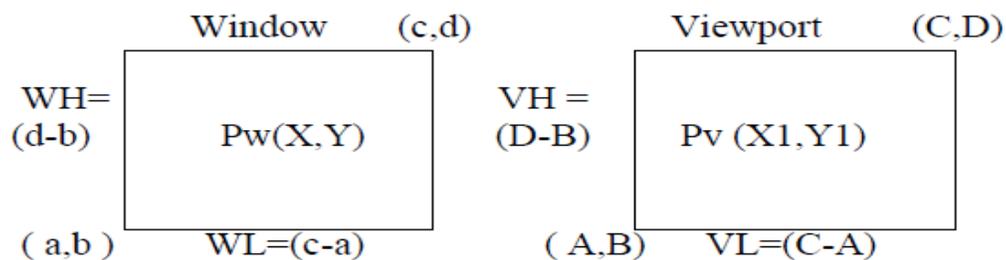
1- **Window Shift**

Shift the lower left corner of the window to the origin:

$$W = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ -a & -b & 1 \end{bmatrix}$$

2- Scale the window dimensions to the dimensions of the viewport. The scaling involves a factor of

$$\frac{(C-A)}{(c-a)} \quad \text{in the X direction}$$

$$\frac{(D-B)}{(d-b)} \quad \text{in the Y direction}$$

The matrix of the local scaling is

$$
S = \begin{vmatrix}
\dfrac{(C-A)}{(c-a)} & 0 & 0 \\
0 & \dfrac{(D-B)}{(d-b)} & 0 \\
0 & 0 & 1
\end{vmatrix}
$$

3- Viewport shift

Shift the lower left corner of the viewport from the screen origin to its proper position

$$
V = \begin{vmatrix}
1 & 0 & 0 \\
0 & 1 & 0 \\
A & B & 1
\end{vmatrix}
$$

Multiplying the three matrices in order, we get a single matrix for window to viewport mapping :

$$M = W * S * V$$

Or by using equation

$$X1 = (X - a) * \frac{VL}{WL} + A$$

$$Y1 = (Y - b) * \frac{VH}{WH} + B$$

Where (X,Y) is the point in the window and to be mapped to the point in the viewport (X1 , Y1)

Example : Point P is to be displayed on part of a screen as indicated in the figure. Describe the sequence of transformation that will transform the window shown to the viewport indicated and give the matrix for each. Calculation the coordinates of P where it appears on the screen.

Window	(3,5)	Viewport	(0.8,0.9)

Window P (2.5,3.5) (1,3)
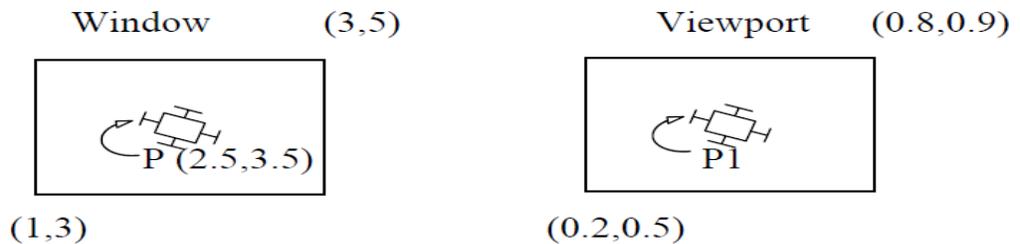
Viewport P1 (0.2,0.5)

Solution

$$W = \begin{array}{|c|c|c|} \hline 1 & 0 & 0 \\ \hline 0 & 1 & 0 \\ \hline -1 & -3 & 1 \\ \hline \end{array}$$

$$S = \begin{bmatrix} \dfrac{0.8 - 0.2}{3 - 1} & 0 & 0 \\[2ex] 0 & \dfrac{0.9 - 0.5}{5 - 3} & 0 \\[2ex] 0 & 0 & 1 \end{bmatrix}$$

$$V = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0.2 & 0.5 & 1 \end{bmatrix}$$

So the single matrix M will be :

$$M = \begin{bmatrix} 0.3 & 0 & 0 \\ 0 & 0.2 & 0 \\ -0.1 & -0.1 & 1 \end{bmatrix}$$

P1 (in viewport) = P (inwindow) * M

$$= \begin{bmatrix} 2.5 & 3.5 & 1 \end{bmatrix} * \begin{bmatrix} 0.3 & 0 & 0 \\ 0 & 0.2 & 0 \\ -0.1 & -0.1 & 1 \end{bmatrix}$$

$$= \ (\ 0.65\ ,\ \ 0.6\ )\ \text{in the viewport}$$

OR by using equation

$$X1 = (\ 2.5\text{-}1) * \ \frac{0.6}{2} + 0.2 \ = \ 0.65$$

$$Y1 = (\ 3.5 - 3) * \ \frac{0.9 - 0.5}{5\text{-}3} + 0.5 \ = \ 0.6$$