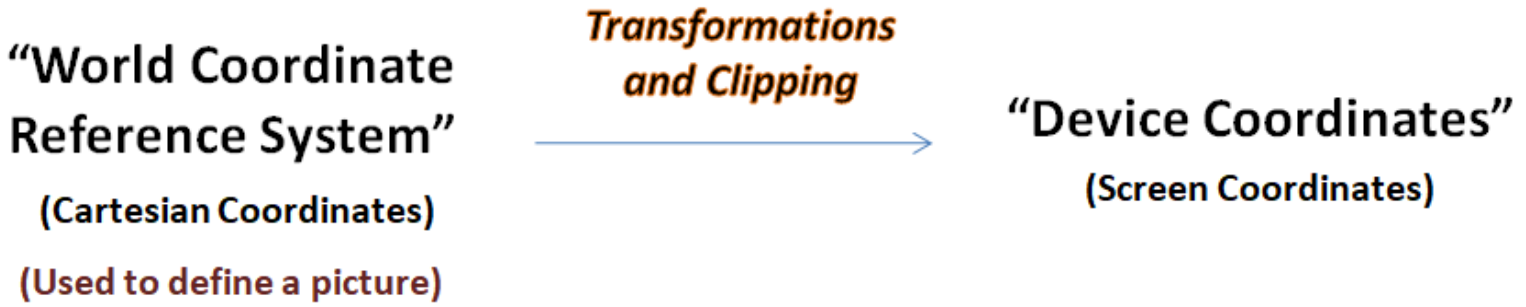
COMPUTER GRAPHICS (RCS-603)

2D VIEWING AND VIEWING TRANSFORMATIONS

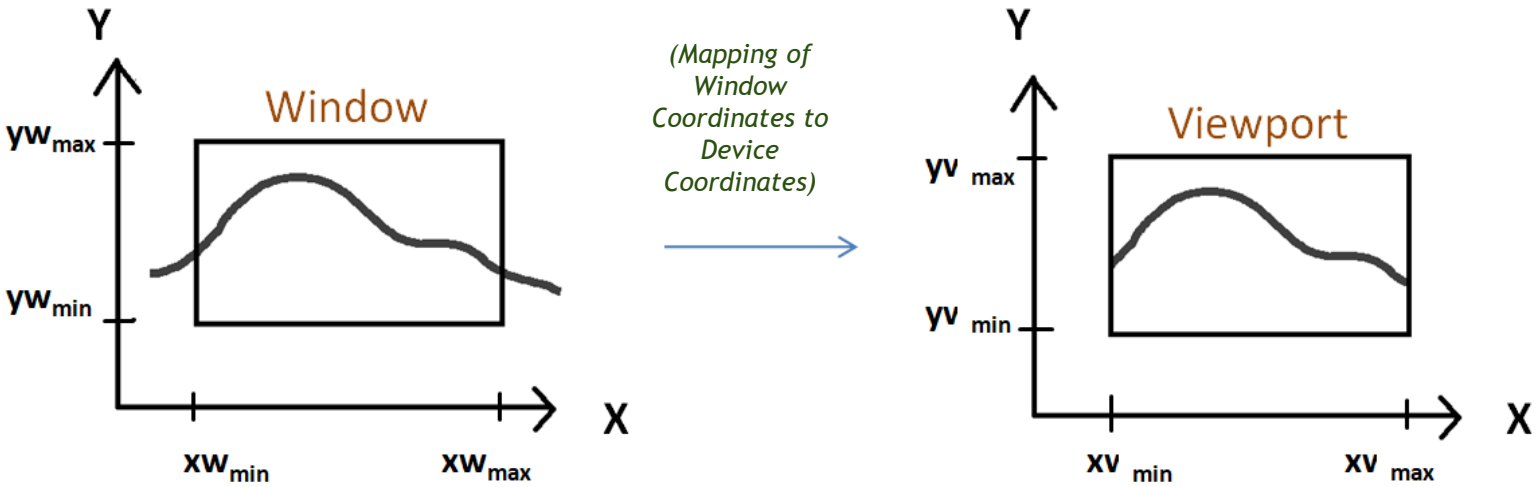
Date: 23/03/2020

2D Viewing

- A graphics package allows a user to specify which part of a picture is to be displayed and where that part is to be placed on the display device.



Viewing Transformation



World Coordinates **Device Coordinates**

- **Viewing Transformation** is the mapping of coordinates of points and lines that form the picture into appropriate coordinates on the display device.

Viewing Transformation

- **Window to Viewport Transformation or Windowing Transformation** is the process of transforming a 2D world-coordinate objects to device coordinates. Objects inside the world or clipping window are mapped to the viewport which is the area on the screen where world coordinates are mapped to be displayed.

Viewing Transformation

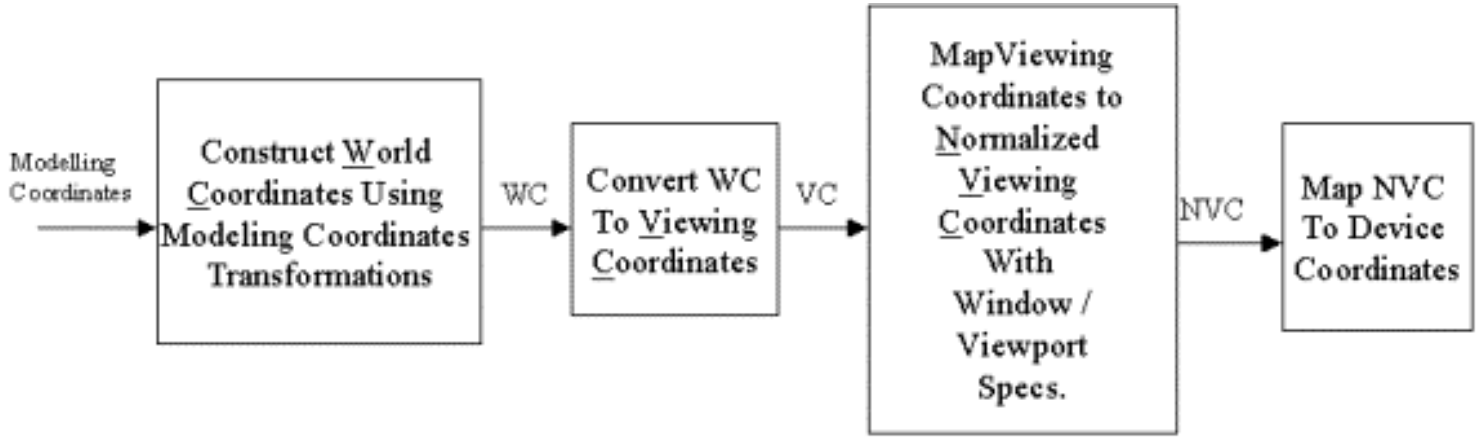
- ***World coordinate system (WCS)*** is the right handed Cartesian co-ordinate system where we define the picture to be displayed.
- A finite region in the WCS is called the ***Window***.
- An area on a display device to which a window is mapped is called a **Viewport**.
- Window defines what is to be viewed, whereas, Viewport defines where it is to be displayed.
- The corresponding coordinate system on the display device where the image of the picture is displayed is called the ***Device Coordinate system***.
- Mapping the *window* onto a sub-region of the display device called the *viewport* is called the ***Viewing Transformation***.
- ***Normalized device coordinate (NDC)*** is the display area of the virtual display device corresponding to a unit square. The lower left handed corner is the origin of the coordinate system.
- Mapping the window in the world coordinate space to viewport in NDC space is called the ***Normalization Transformation***.

Viewing Transformation

- **Step 1:** Construct a scene in world coordinates using output primitives and transformations.
- **Step 2:** To obtain a particular orientation for the window, we set up a 2D viewing coordinate system in world coordinates plane and define a window in the viewing coordinate system.
- **Step 3:** Once viewing coordinate reference frame has been set up, we can set up world coordinate to viewing coordinates. We can then define a viewport in normalized coordinates (0-1) and map the viewing coordinates description of the scene to normalized coordinates.
- **Step 4:** All parts lying outside the viewport are clipped and contents are transferred to device coordinates.

Viewing Transformation

- By changing the position of the viewport, we can view objects at different positions on display area of an output device. we can also change the size and proportions of the displayed objects by varying the size of the viewport.



• **2D Viewing Transformation Pipeline**

Viewing Transformation

- It may be possible that the size of the Viewport is much smaller or greater than the Window. In such cases, we have to increase or decrease the size of the Window according to the Viewport. In order to maintain the same relative placement of the point in the viewport as in the window, we require:

$$\frac{xv - xv_{min}}{xv_{max} - xv_{min}} = \frac{xw - xw_{min}}{xw_{max} - xw_{min}} \quad \text{.....equation 1}$$

$$\frac{yv - yv_{min}}{yv_{max} - yv_{min}} = \frac{yw - yw_{min}}{yw_{max} - yw_{min}}$$

- Solving these equations for the viewport position (xv, yv), we have:

$$xv = xv_{min} + (xw - xw_{min})sx$$
$$yv = yv_{min} + (yw - yw_{min})sy \quad \text{.....equation 2}$$

- Where scaling factors are:

$$sx = \frac{xv_{max} - xv_{min}}{xw_{max} - xw_{min}} \qquad sy = \frac{yv_{max} - yv_{min}}{yw_{max} - yw_{min}}$$

Viewing Transformation

- Equation (1) and Equation (2) can also be derived with a set of transformations that converts the window or world coordinate area into the viewport or screen coordinate area. This conversation is performed with the following sequence of transformations:

1. Perform a scaling transformation using a fixed point position (xw_{min},yw_{min}) that scales the window area to the size of the viewport.
2. Translate the scaled window area to the position of the viewport. Relative proportions of objects are maintained if the scaling factors are the same (sx=sy). Otherwise, world objects will be stretched or contracted in either x or y direction when displayed on an output device.

Workstation Transformation

- From normalized coordinates, object descriptions are mapped to various display devices.
- Any number of output devices can be opened in a particular application, where window to viewport transformations can be performed for each output device.
- This mapping is called ***Workstation Transformation*** (It is accomplished by selecting a window area in normalized space and a viewport area in the coordinates of the display device).
- Workstation transformation can be used to partition a view so that different parts of normalized space can be displayed on various output devices.

Workstation Transformation

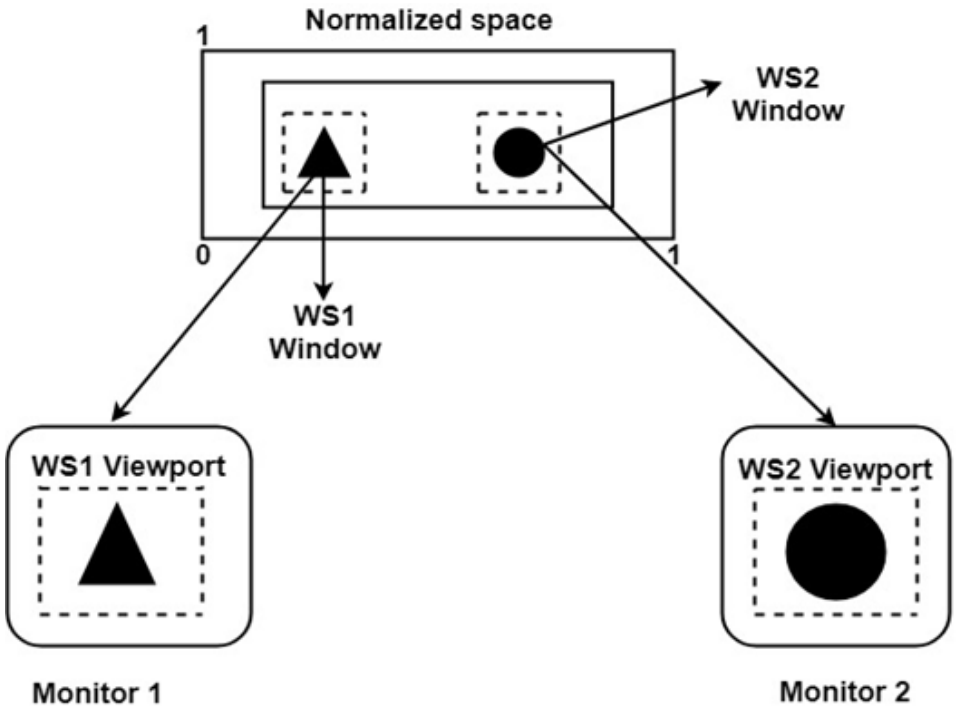


Fig:Mapping selected parts of a scene in normalized coordinates to different video monitors with workstation transformation.

Advantages of Viewing Transformation

We can display picture at device or display system according to our need and choice, where:

- World coordinate system is selected according to the application program.
- Screen coordinate system is chosen according to the need of design.
- Viewing transformation is selected as a bridge between the world and screen coordinate.

THANK YOU