Computer Graphics - Introduction

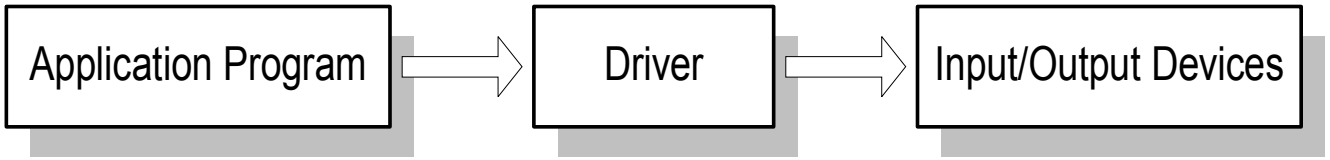
Human-Centered CAD Lab.

Basic Theories in Computer Graphics

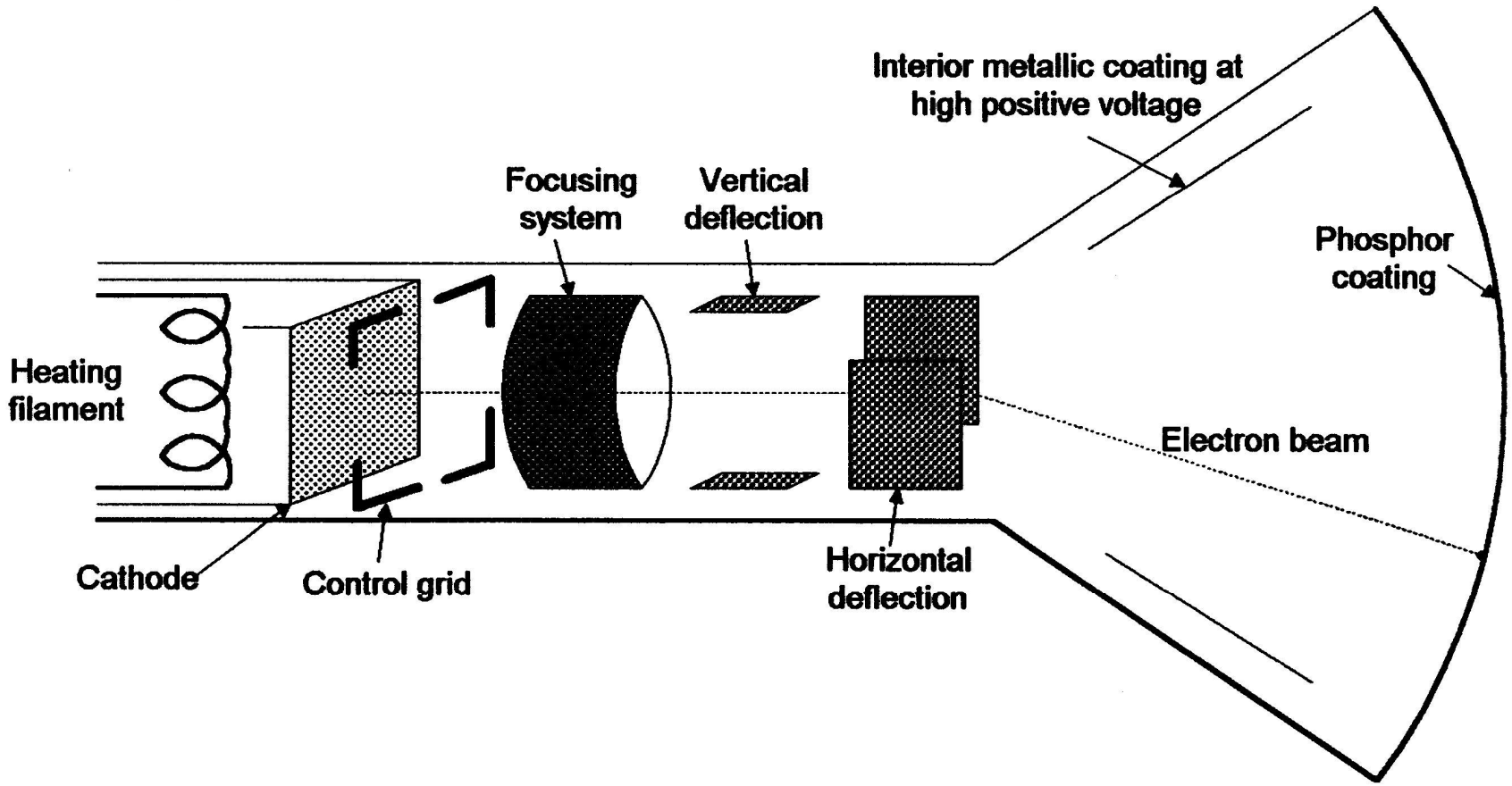
- Computer graphics is an essential tool in CAD
- Interactive shape manipulation is an essential element of CAD

Graphic Library

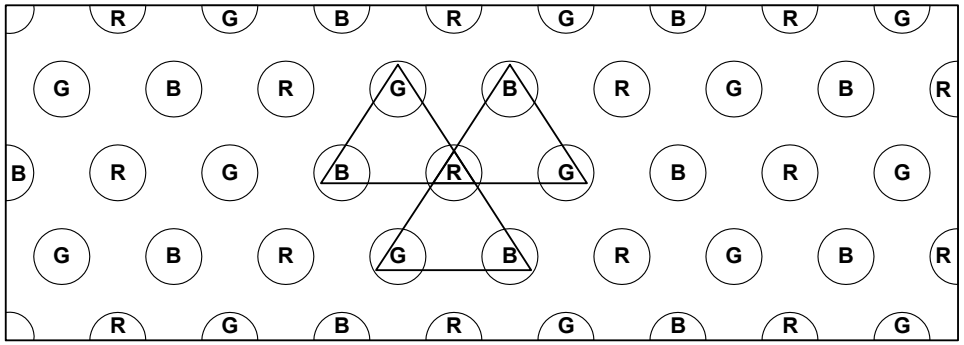
- Driver:
  - Hardware-dependent software to drive a specific graphic device
  - Different graphic devices are driven by different driver routines

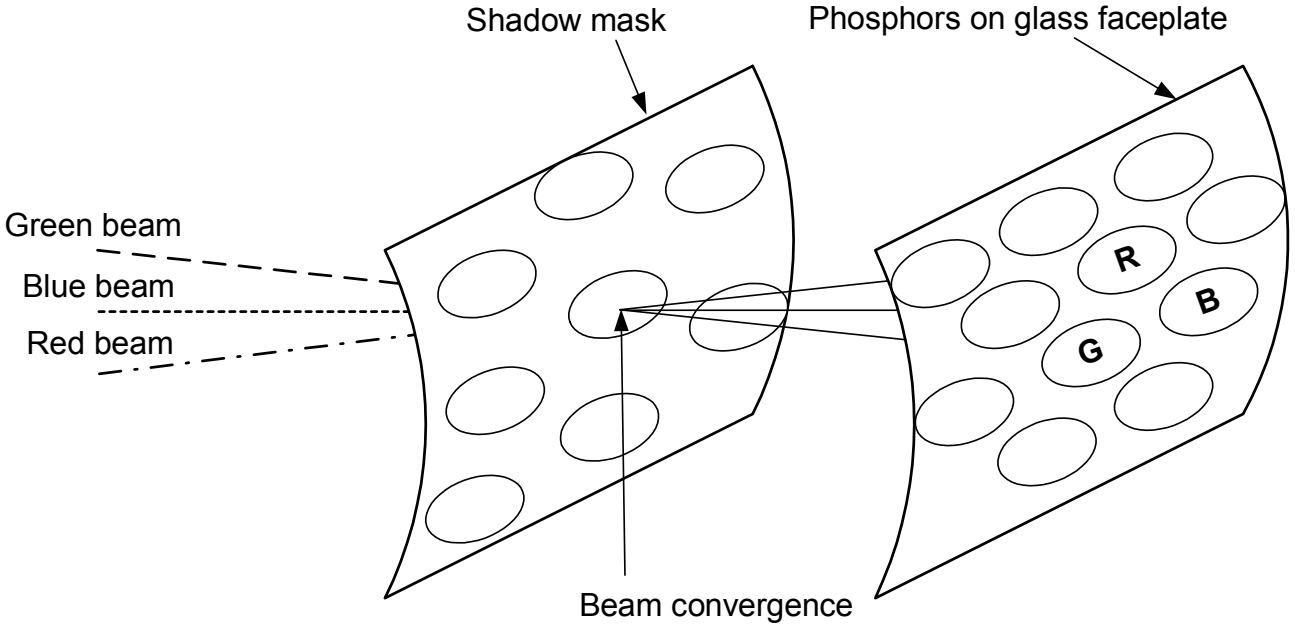


Cathode Ray Tube

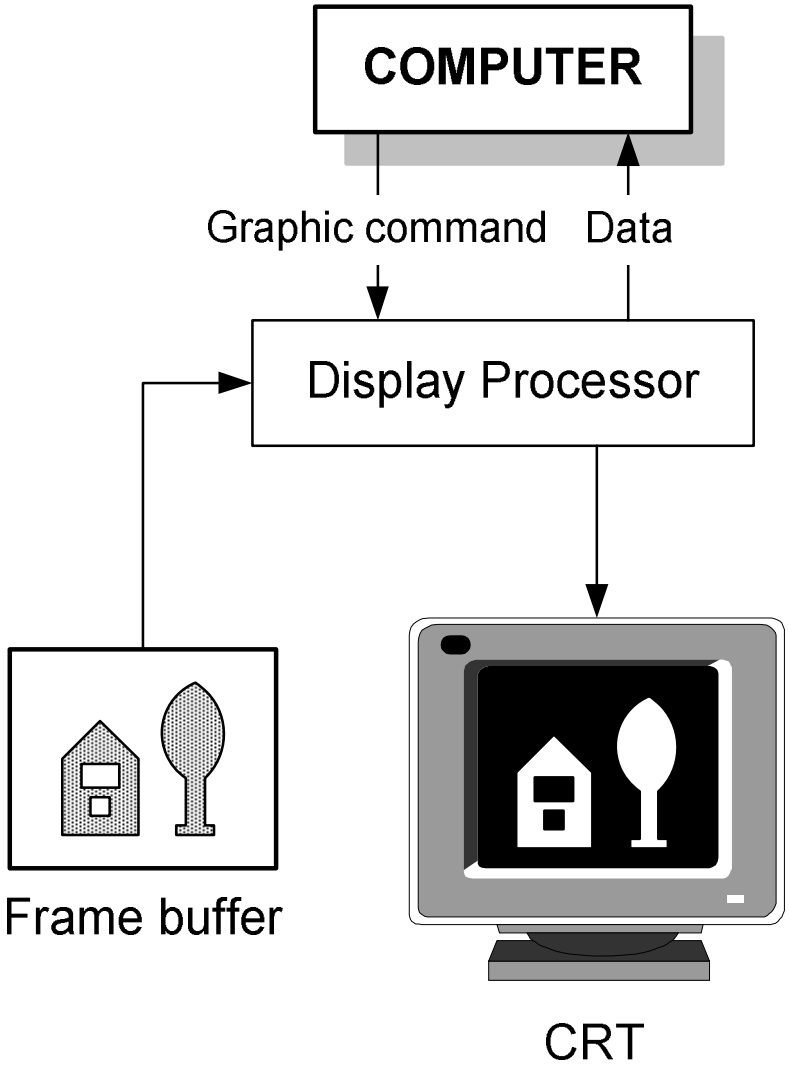


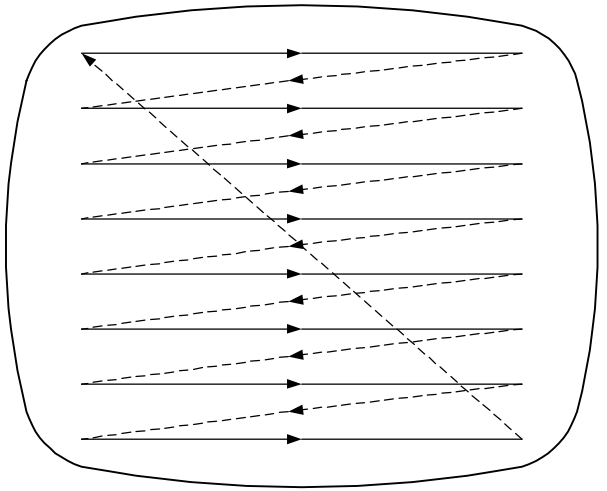
Cathode Ray Tube





Display Process



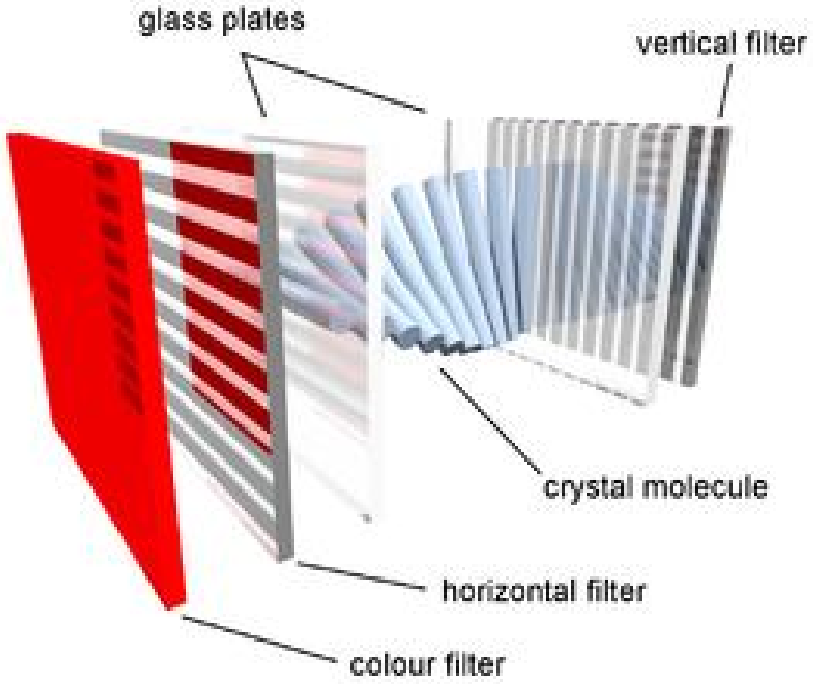


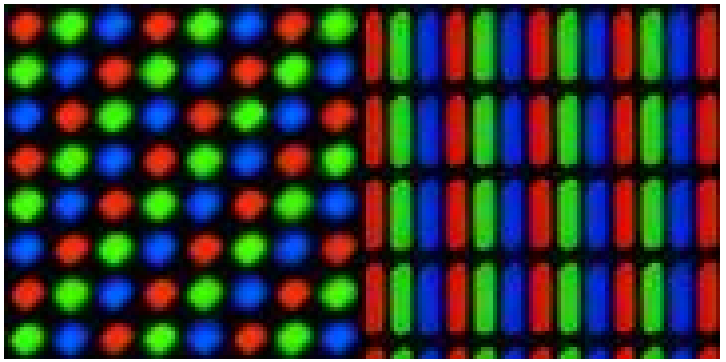
LCD (Liquid Crystal Display)

- Each pixel of an LCD typically consists of a layer of molecules aligned between two transparent electrodes, and two polarizing filters, the axes of transmission of which are perpendicular to each other. With no actual liquid crystal between the polarizing filters, light passing through the first filter would be blocked by the second polarizer.

- Molecular orientation of liquid crystal is twisted according to the electric field and polarization of the incident light is rotated through liquid crystal layer.

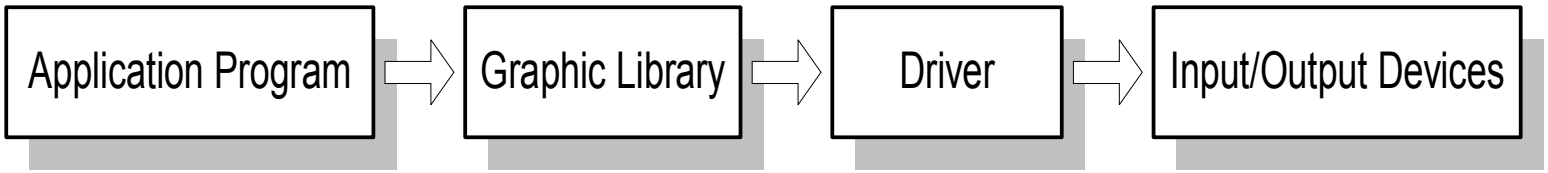
LCD (Liquid Crystal Display)





Graphic Library – cont'

- Graphic Library
  - Collection of sub-programs performing graphic functions by calling driver routines
  - Each subprogram is implemented by driver routines



Graphic Library – cont'

- Any Graphic Library can support limited drivers
- Application program written with a specific graphic library may have to be rewritten when a graphic device is not supported by the used graphic library
- Better to have same subprogram names and usage in all graphic libraries

Graphic Library – cont'

- CORE Graphic System in 1977 by SIGGRAPH (Special Interest Group on Computer Graphics) under ACM (Association for Computing Machinery)
- Weak for raster graphics
- GKS (Graphic Kernel System)
  - Standard for 2D graphics
  - GKS – 3D

Graphic Library – cont'

- PHIGS (Programmer's Hierarchical Interactive Graphics System) by ISO
  - Support dynamic display, better user interaction
- PEX (PHIGS Extension to X)
  - Extension of PHIGS by using windowing capability of X
- GL, OpenGL

Coordinate Systems

- Reference coordinate systems to specify the locations of points on the objects and their projected locations on the screen

- Device Coordinate System
  - Horizontal axis of screen becomes u-axis, vertical axis becomes v-axis
  - u,v coordinates (integer value, number of pixels) define the location in screen
  - Different graphic devices have different origin location and the range of u, v values

Virtual Device Coordinate System

- Origin is located at the same location with respect to the screen
- Ranges of u, v values are same
- Location in screen is provided to the device driver in virtual coordinates, then driver changes the coordinates into specific device coordinates

World Coordinate System

- Reference coordinate system to describe the whole scene
- Used to describe the location and orientation of objects in the scene
- Used to specify the location of the view point and view site

Model Coordinate System

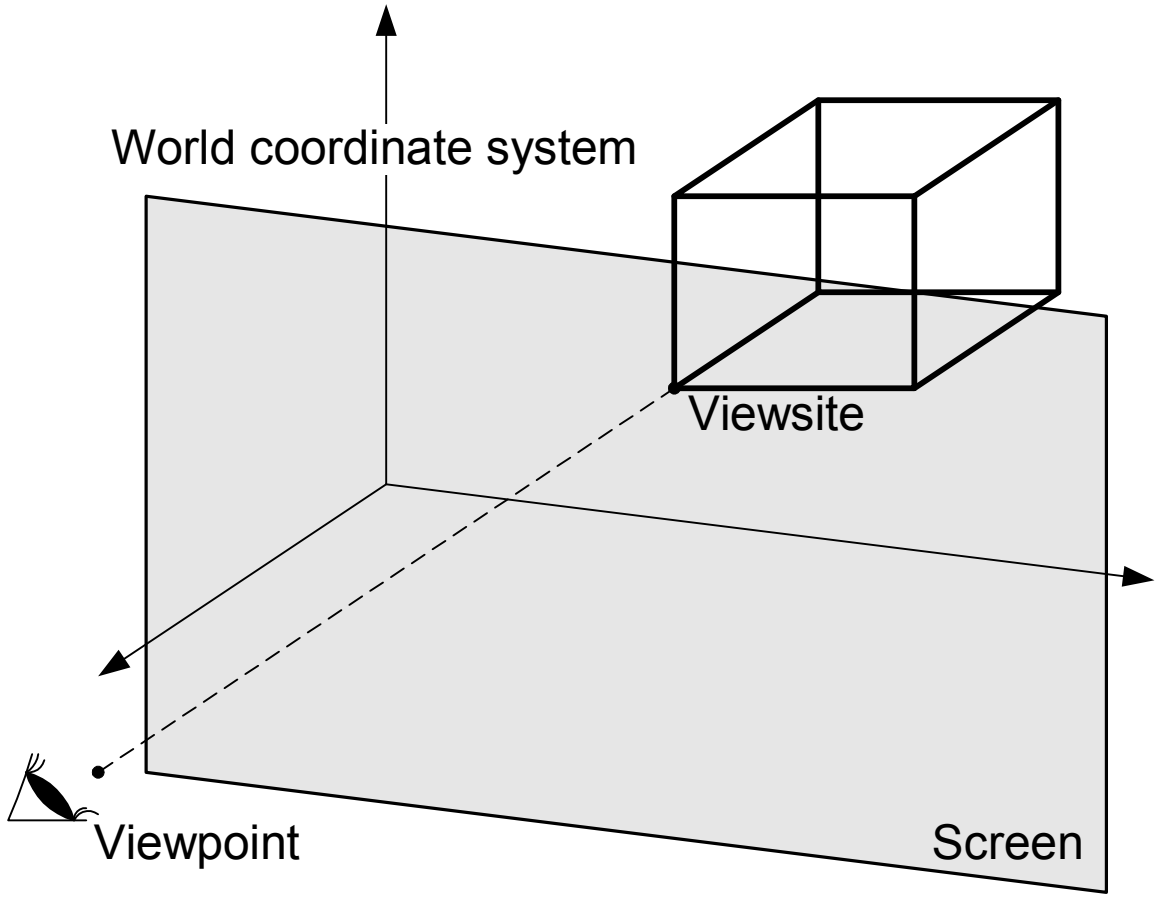
- Coordinate system fixed to each object
- Model coordinates of points on the object do not vary while the model translates and rotates
- Object translation and rotation is described by the location of the origin and the axes orientations of model coordinate system

Viewing Coordinate System

- Used to facilitate the projection calculation of 3D points

- Determined by view point and view site

Viewpoint and viewsite

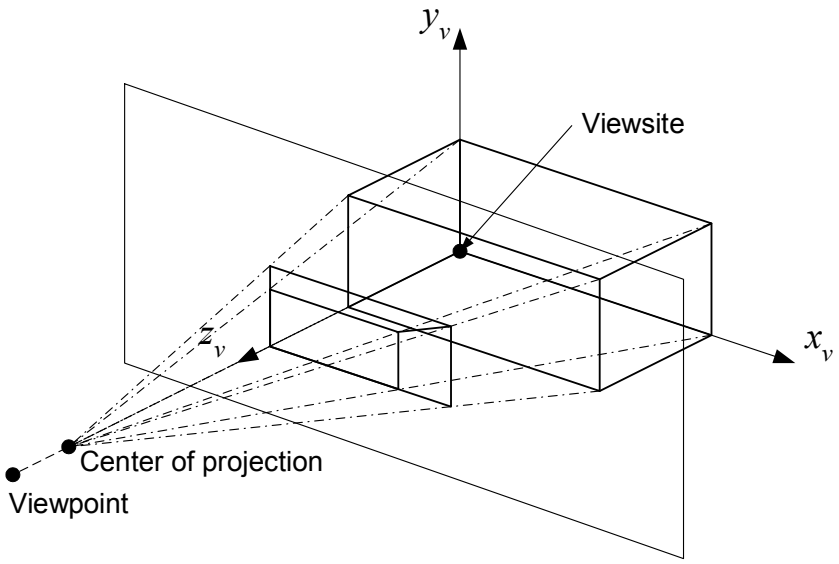


Viewing coordinate system – cont'

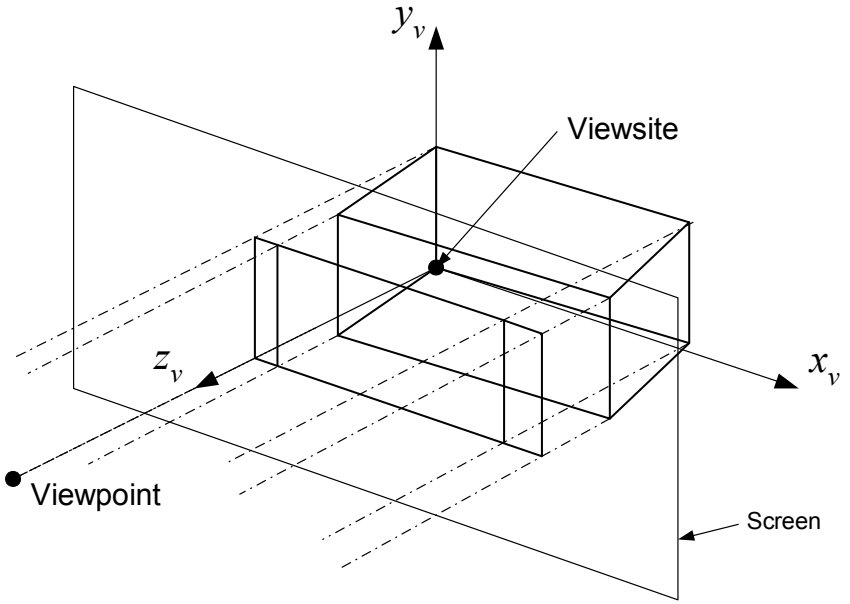
- X_V, Y_V, Z_V coordinate system
  - Origin is at viewsite
  - Z_V is from viewsite to viewpoint
  - Y_V is in the vertical upper direction in the screen
  - X_V points to the right in the screen when viewed from view point

- OpenGL
  - Origin is at viewpoint
  - Z_V is from viewpoint to viewsite
  - Left-handed coordinate system

Two types of projection



Perspective projection

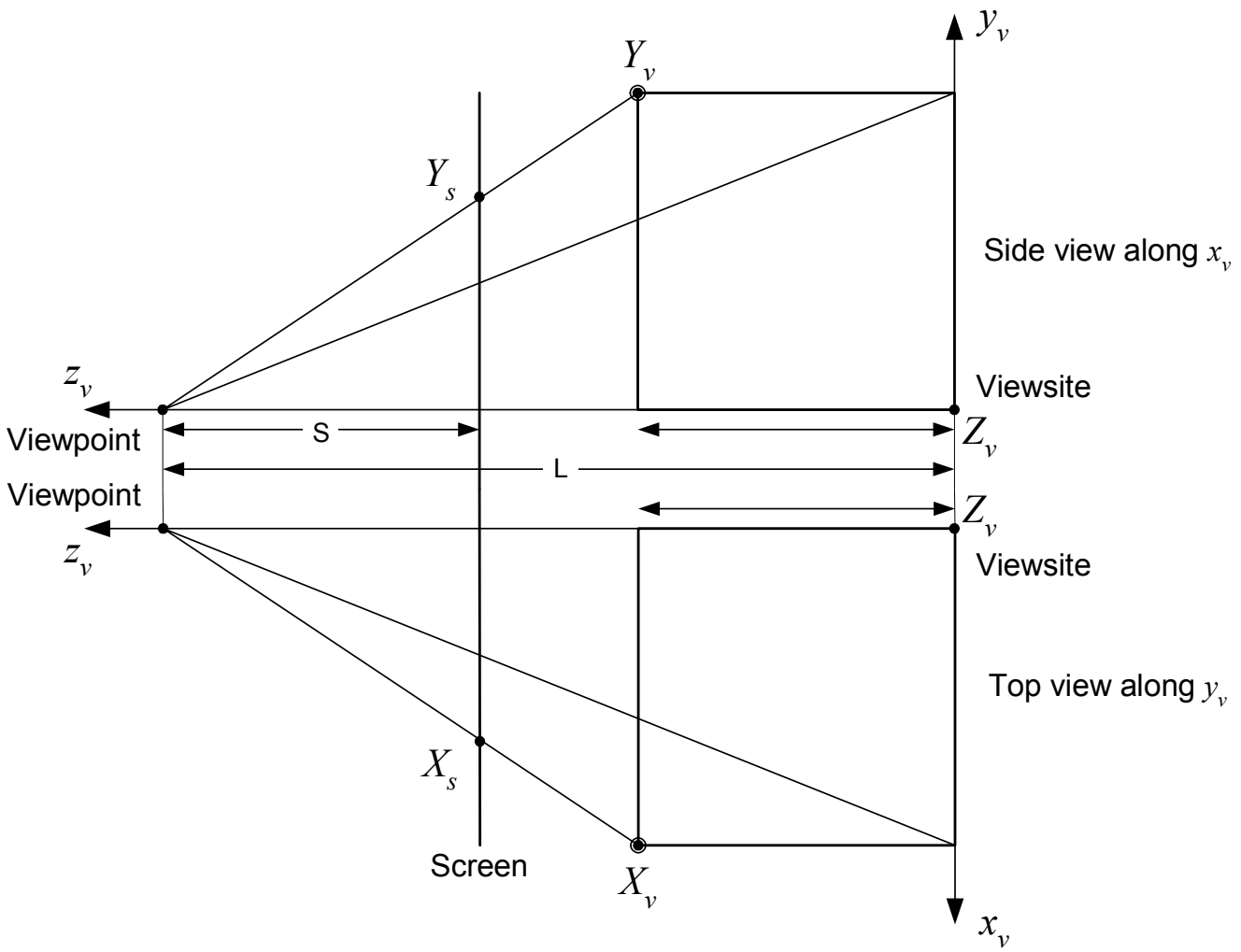


Parallel projection

Parallel projection

- Point on the objects are represented by X_V, Y_V, Z_V coordinates and use X_V, Y_V for screen coordinates

Perspective projection



Perspective projection – cont'

- Similarity rule is used to determine screen coordinates from X_V, Y_V, Z_V coordinates

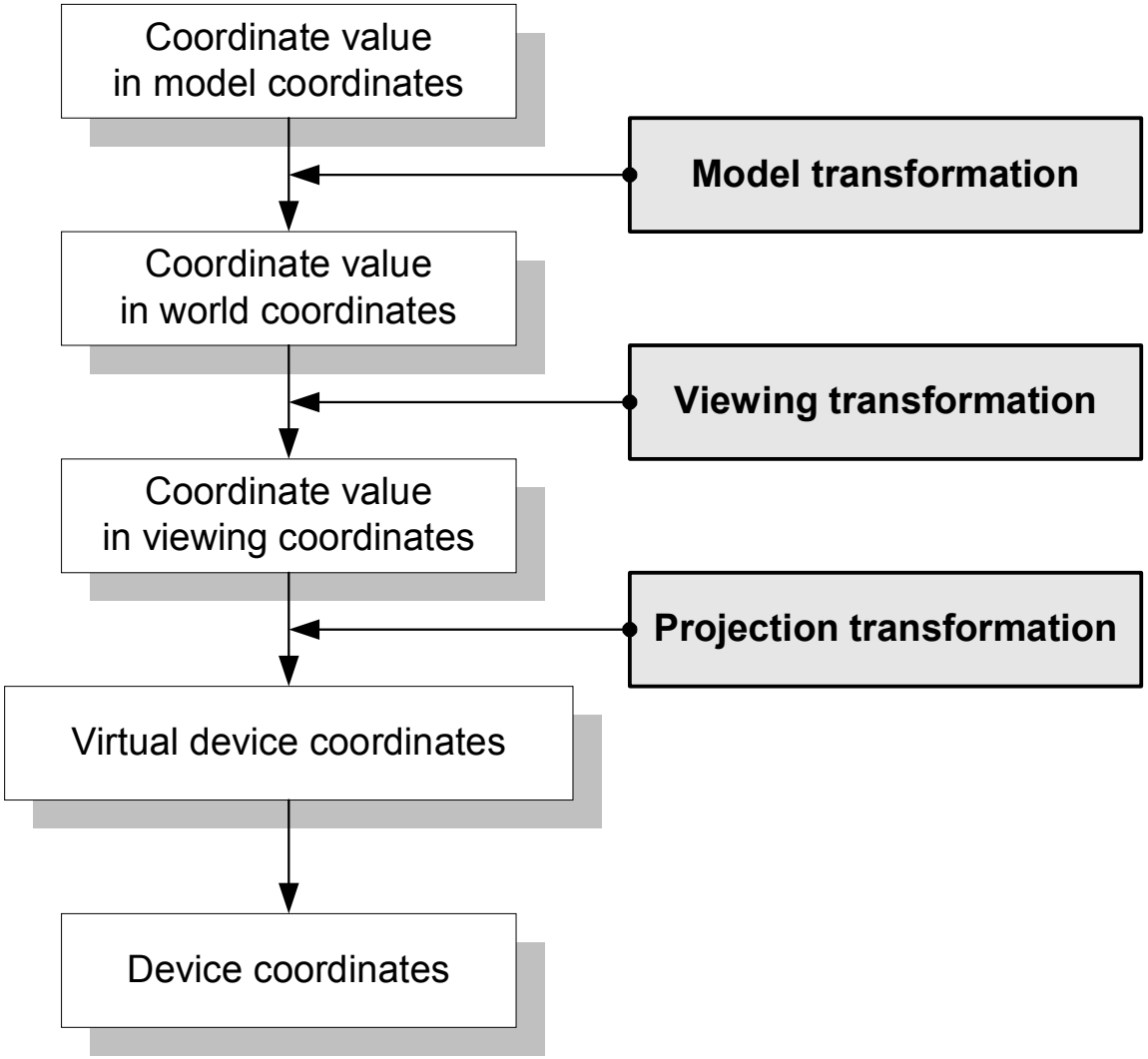
$$L : X_V = S : X_S$$

$$X_S = \frac{S}{L} X_V$$

$$Y_S = \frac{S}{L} Y_V$$

- Y_V is obtained by projecting up-vector onto the screen
  - By specifying Up-vector, camera rotation is fixed

Transformation between coordinate systems



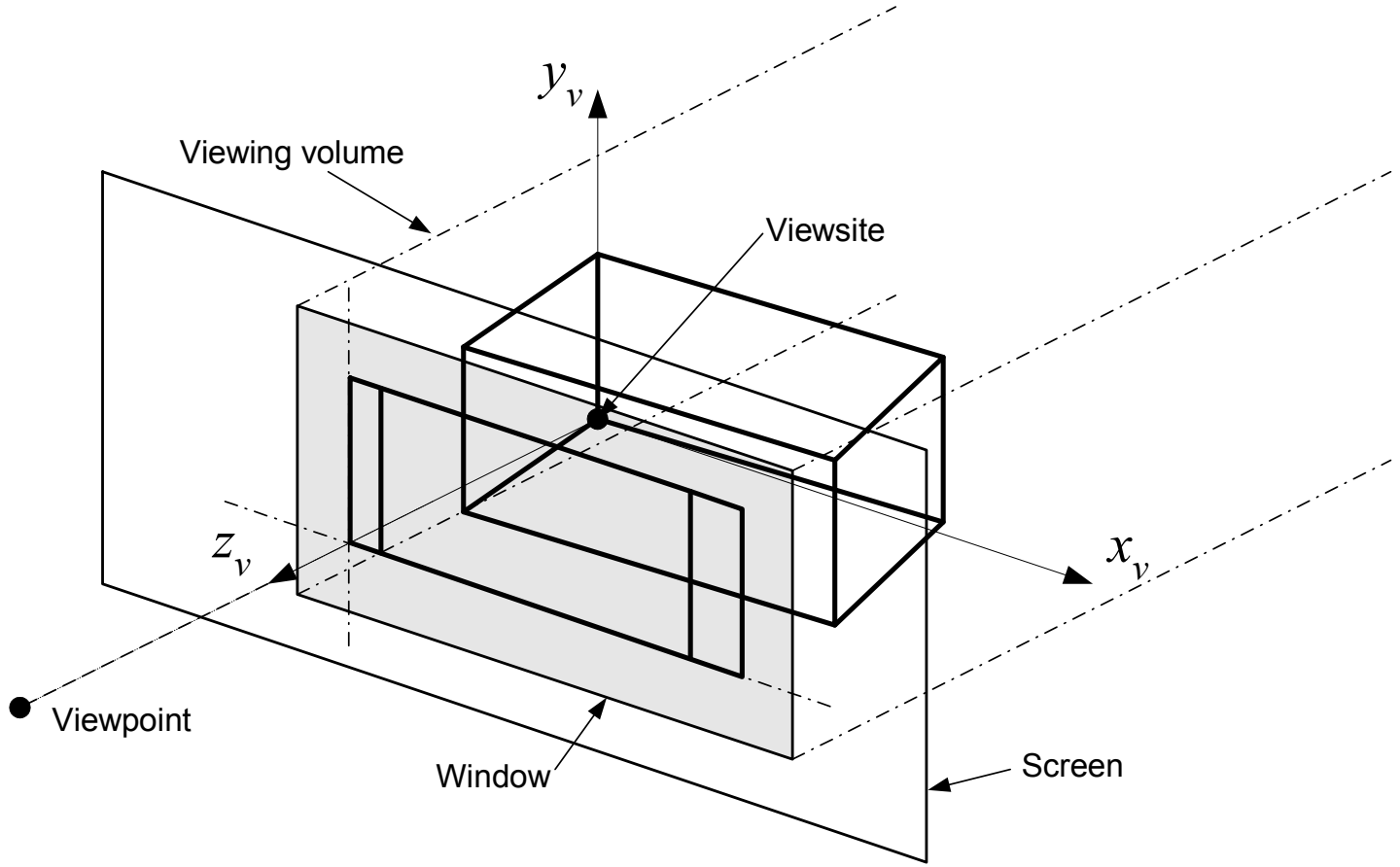
Viewing volume

- To specify the volume to display

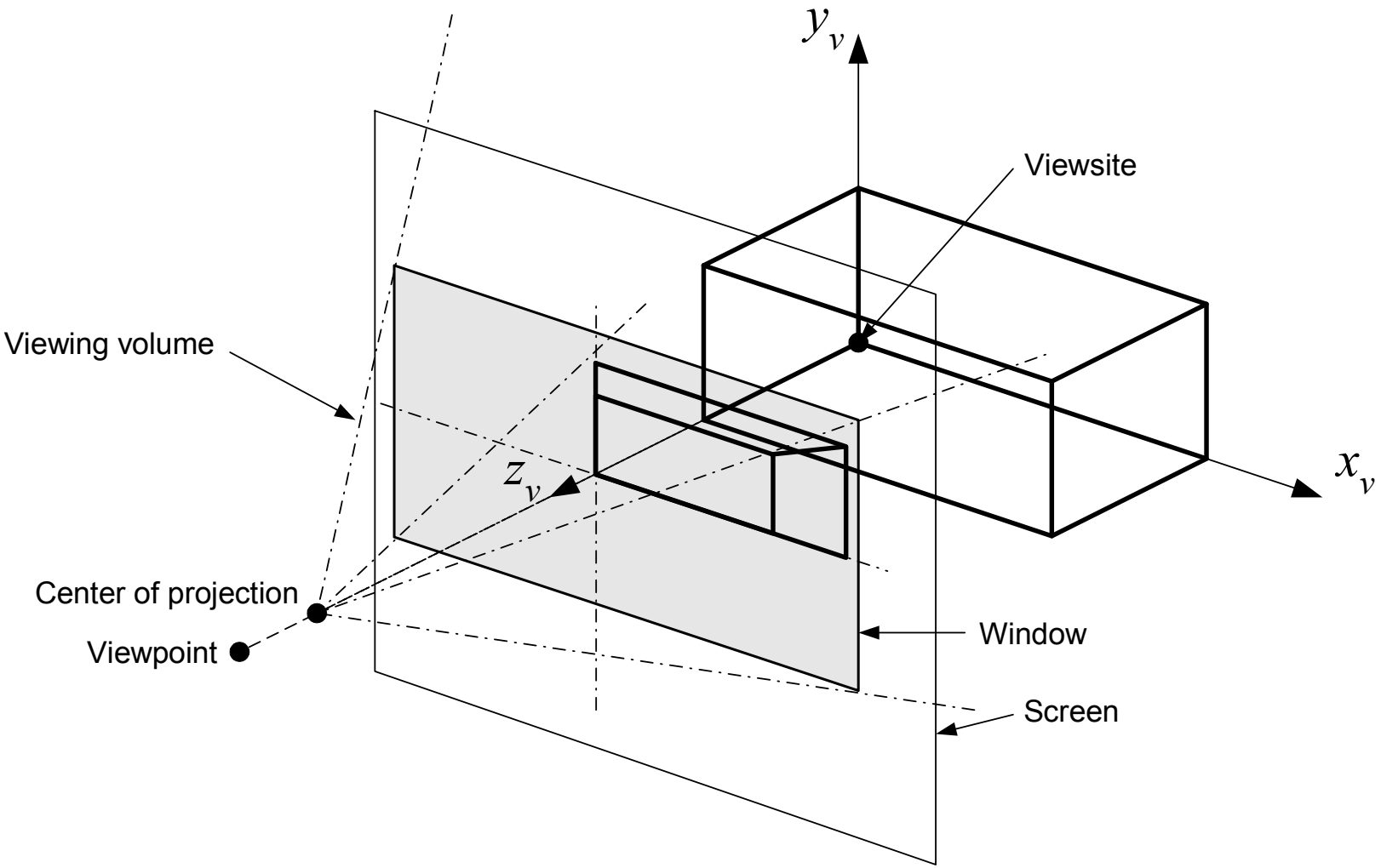
- Similar to the window when we look outside from inside a house

Viewing volume for parallel projection

- Horizontal and vertical size is specified by X_V, Y_V coordinates

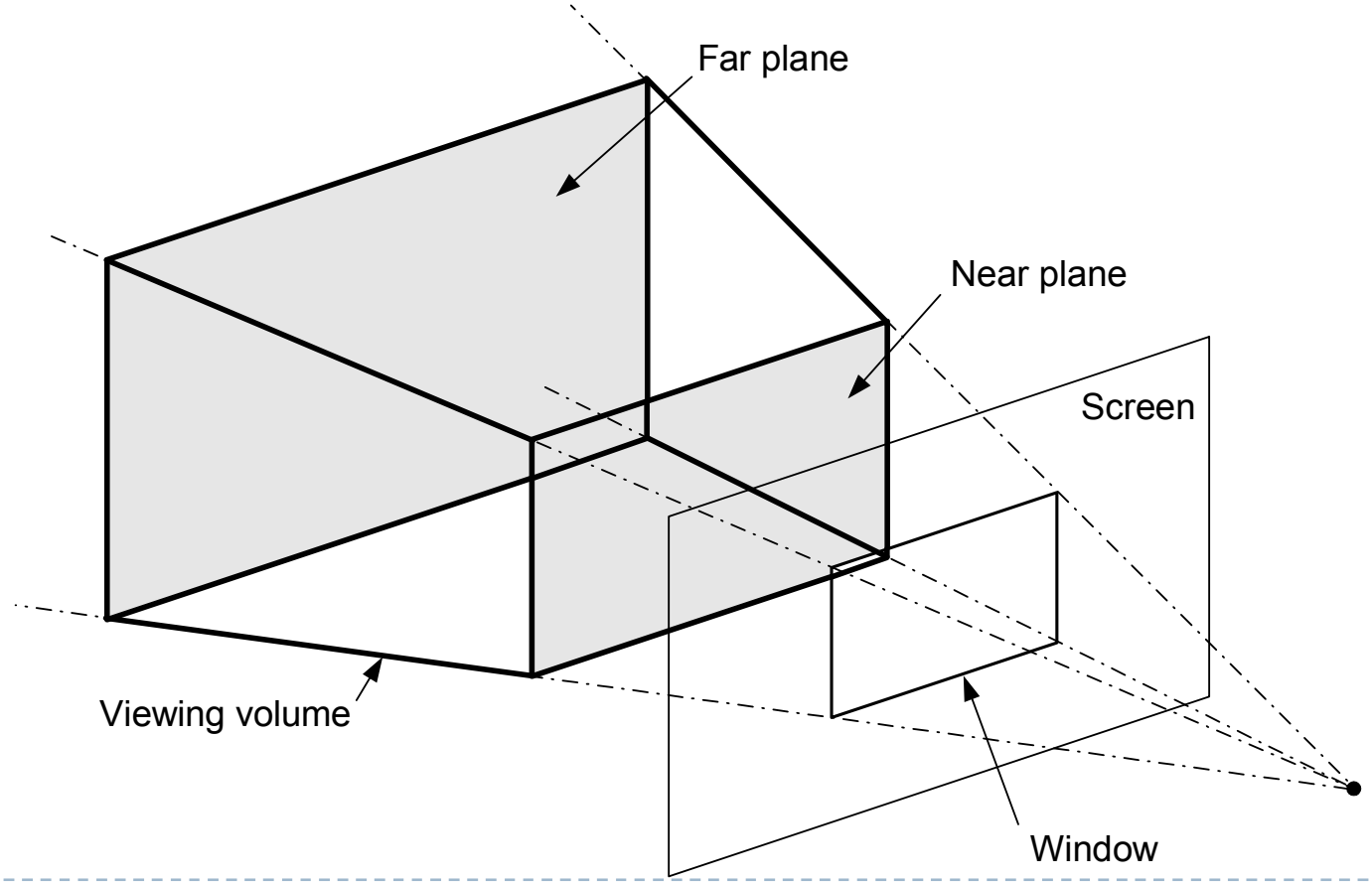


Viewing volume for perspective projection



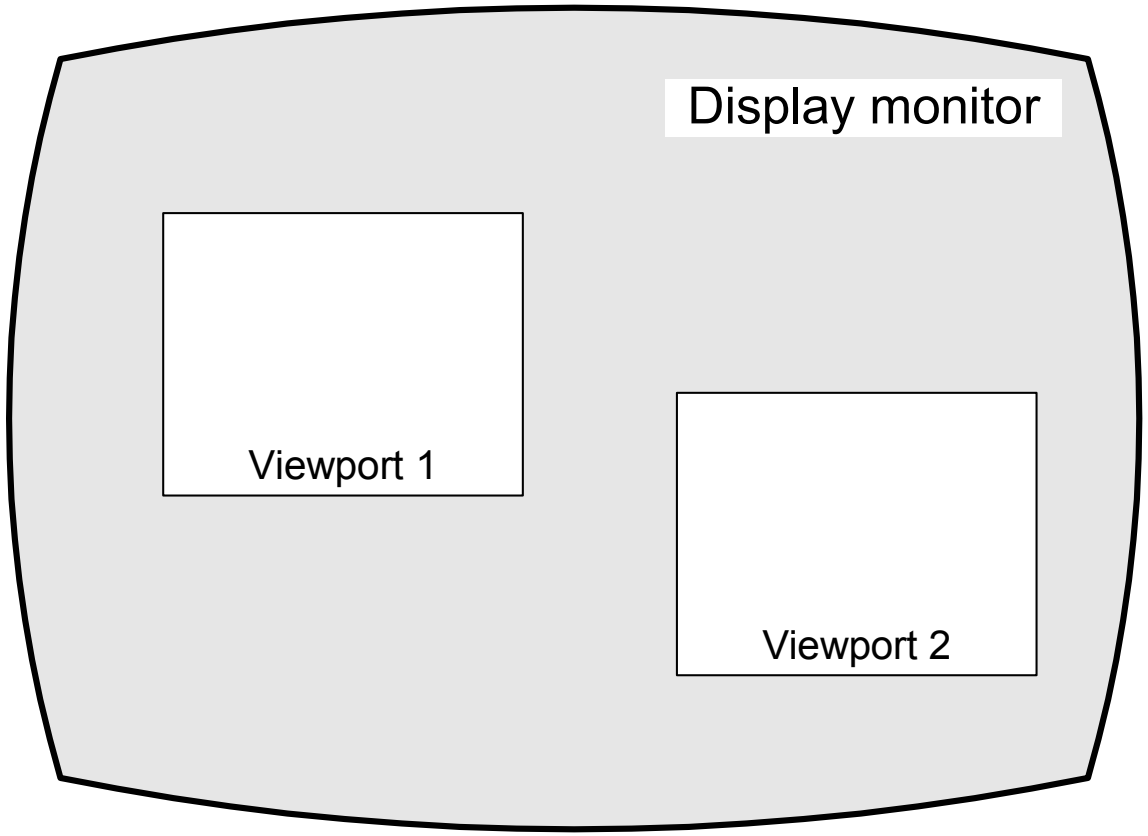
Viewing volume: Near plane and far plane

- Near plane, Far plane:
  - Used to eliminate entities too far or near from view point



View port

- Region on graphic monitor where screen is projected by viewport mapping



View port – cont’

- View port is specified by using virtual device coordinates

- Location on screen
  → Location on view port
  by scaling and translation

- Same aspect ratio is desired