CS 543: Computer Graphics
Lecture 2 (Part 1): 2D Graphic Systems

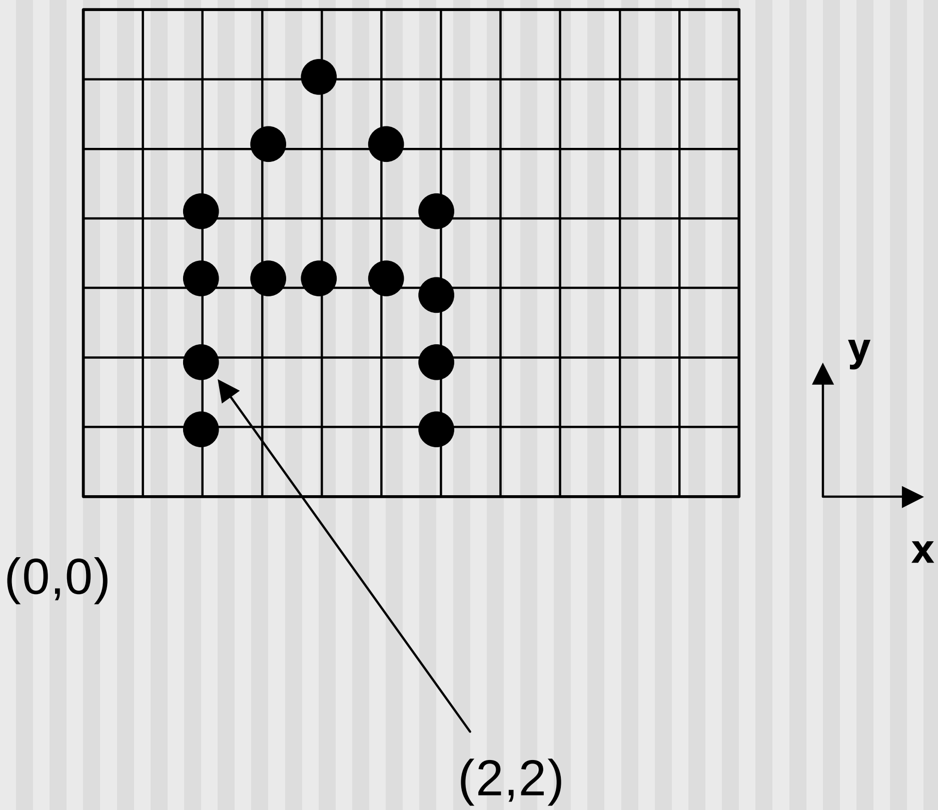
Emmanuel Agu

2D Graphics: Coordinate Systems

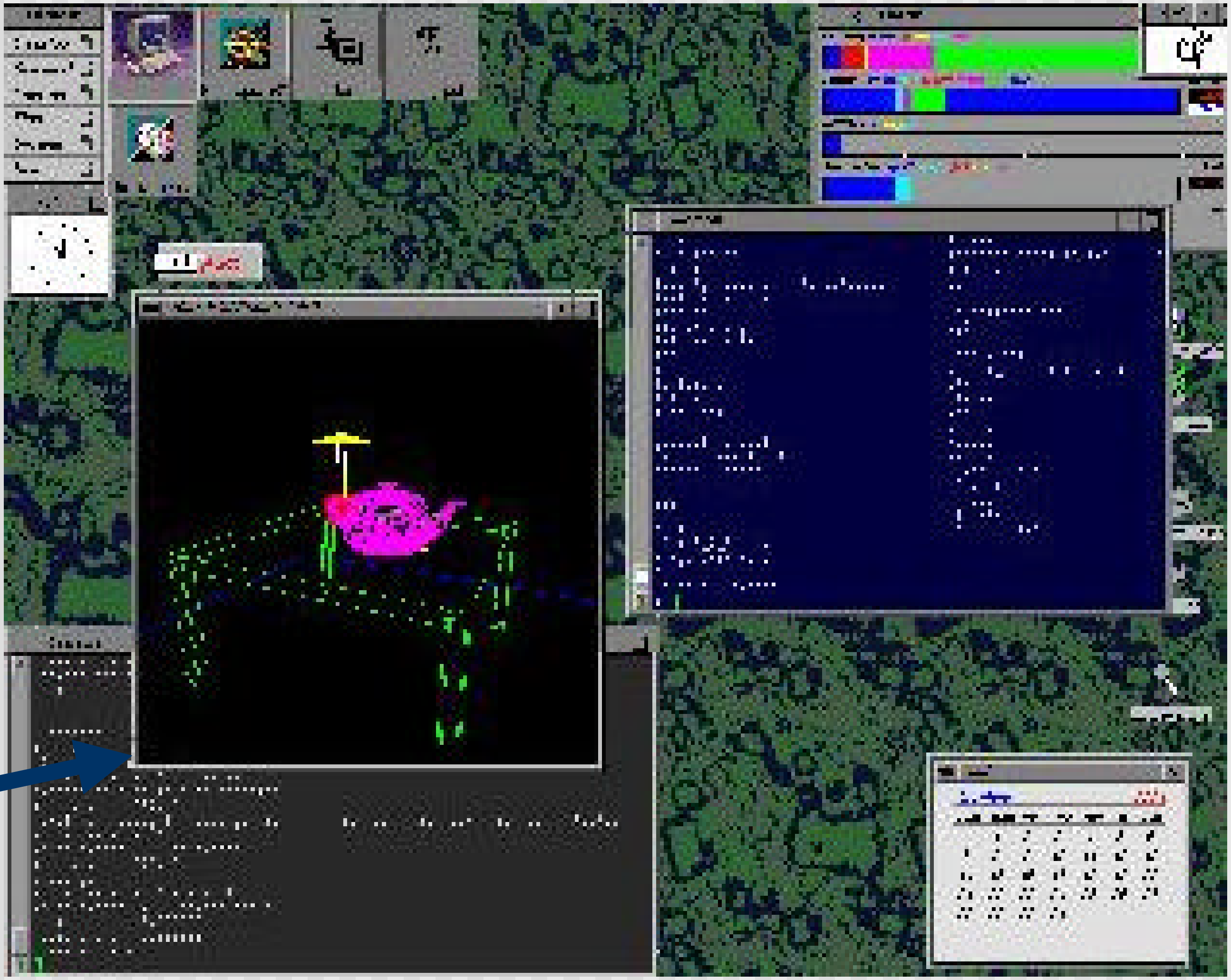
- Screen coordinate system
- World coordinate system
- World window
- Viewport
- Window to Viewport mapping

Screen Coordinate System

- Screen: 2D coordinate system (WxH)
- 2D Regular Cartesian Grid
- Origin (0,0) at lower left corner (OpenGL convention)
- Horizontal axis – x
- Vertical axis – y
- Pixels: grid intersections



Screen Coordinate System



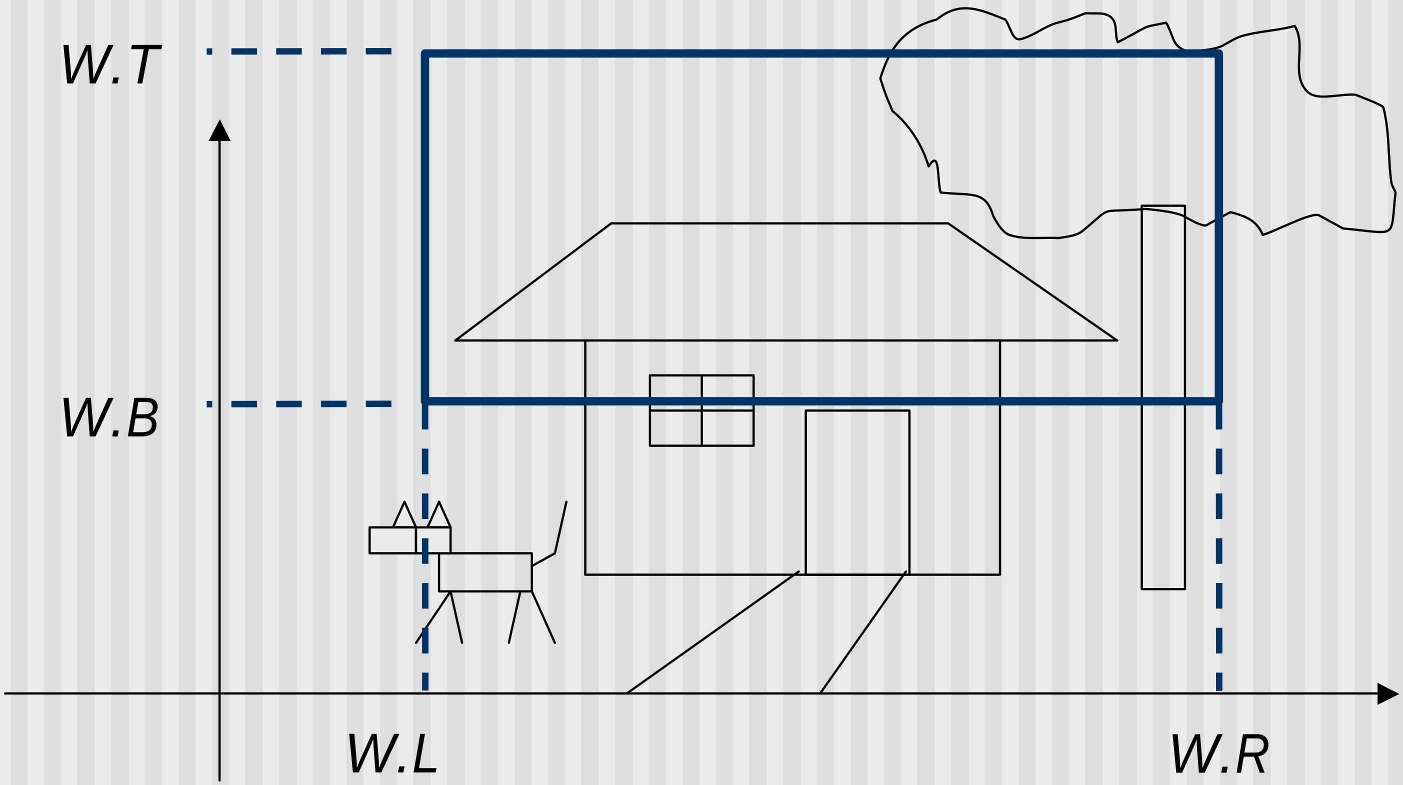
(0,0)

World Coordinate System

- Problems with drawing in screen coordinates:
  - Inflexible
  - Difficult to use
  - One mapping: not application specific
- World Coordinate system: application-specific
- Example: drawing dimensions may be in meters, km, feet, etc.

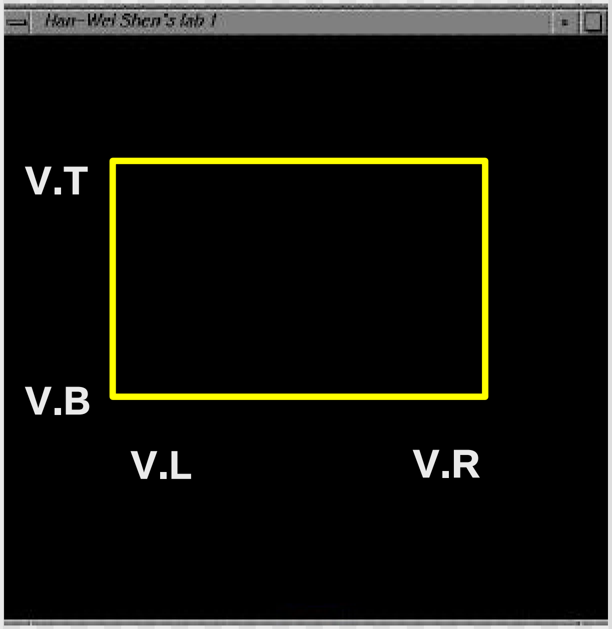
Definition: World Window

- World Window: rectangular region of drawing (in world coordinates) to be drawn
- Defined by *W.L, W.R, W.B, W.T*



Definition: Viewport

- Rectangular region in the screen used to display drawing
- Defined in screen coordinate system



Window to Viewport Mapping

- Would like to:
  - Specify drawing in world coordinates
  - Display in screen coordinates
- Need some sort of mapping
- Called Window-to-viewport mapping
- Basic W-to-V mapping steps:
  - Define a world window
  - Define a viewport
  - Compute a mapping from window to viewport

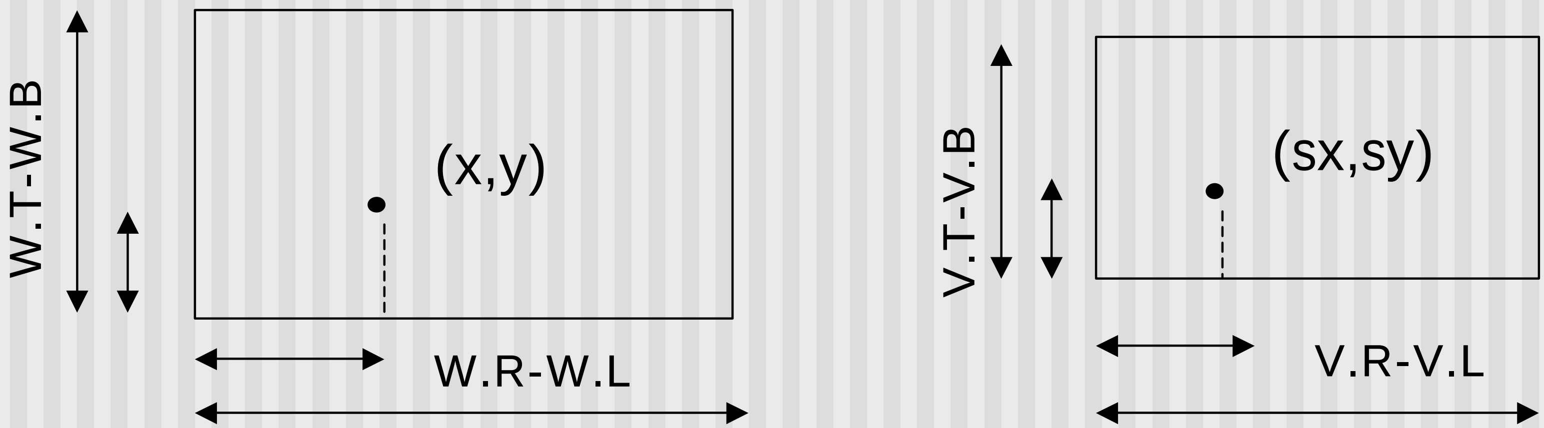
Window to Viewport Mapping (OpenGL Way)

- Define window (world coordinates):
  - **gluOrtho2D(left, right, bottom, top)**
  - **Note:** gluOrtho2D is member of glu library
- Define Viewport (screen coordinates):
  glViewport(left, bottom, right-left, top-bottom)
- All subsequent drawings are automatically mapped
- Do mapping before any drawing **(glBegin( ), glEnd( ))**
- Two more calls you will encounter to set up matrices:
  - **glMatrixMode(GL_PROJECTION)**
  - **glLoadIdentity( )**
- Type in as above for now, will explain later
- Look at figure 3.2, pg 93

Window to Viewport Mapping (Our Way)

- How is window-to-viewport mapping done?
- Trigonometry: derive Window-to-Viewport mapping
- Basic principles:
  - Calculate ratio: proportional mapping ratio (NO distortion)
  - Account for offsets in window and viewport origins
- You are given:
  - World Window: W.R, W.L, W.T, W.B
  - Viewport: V.L, V.R, V.B, V.T
  - A point (x,y) in the world
- Required: Calculate corresponding point (s.x, s.y) in screen coordinates

Window to Viewport Mapping (Our Way)



$$\frac{(x - W.L)}{W.R - W.L} = \frac{Sx - V.L}{V.R - V.L}$$

$$\frac{(y - W.B)}{W.T - W.B} = \frac{Sy - V.B}{V.T - V.B}$$

Window to Viewport Mapping (Our Way)

Solve for Sx, Sy in terms of x, y:

$$\frac{(x - W.L)}{W.R - W.L} = \frac{Sx - V.L}{V.R - V.L}$$

$$\frac{(y - W.B)}{W.T - W.B} = \frac{Sy - V.B}{V.T - V.B}$$

$$Sx = \left(\frac{V.R - V.L}{W.R - W.L}\right)x - \left(\frac{V.R - V.L}{W.R - W.L}W.L - V.L\right)$$

$$= Ax - (A(W.L) - V.L)$$

$$Sy = \left(\frac{V.T - V.B}{W.T - W.B}\right)y - \left(\frac{V.T - V.B}{W.T - W.B}W.B - V.B\right)$$

$$= By - (B(W.B) - V.B)$$

Window to Viewport Mapping (Our Way)

Solve, given the formulas:

$$Sx = Ax - \left(A(W.L) - V.L\right)$$

$$Sy = By - \left(B(W.B) - V.B\right)$$

What is (Sx,Sy) for point (3.4,1.2) in world coordinates if:

$$W = (W.L, W.R, W.B, W.T) = (0,4,0,2)$$

$$V = (V.L, V.R, V.B, V.T) = (60,380,80,240)$$

Window to Viewport Mapping (Our Way)

Solution:

$$Sx = Ax - \left(A(W.L) - V.L\right)$$

$$A = \frac{V.R - V.L}{W.R - W.L}$$

$$Sy = By - \left(B(W.B) - V.B\right)$$

$$B = \frac{V.T - V.B}{W.T - W.B}$$

$$Sx = 80x + 60 = 332 \qquad Sy = 80y + 80 = 176$$

Hence, point (3.4,1.2) in world = point (332,176) on screen

References

- Hill, 3.1 – 3.2