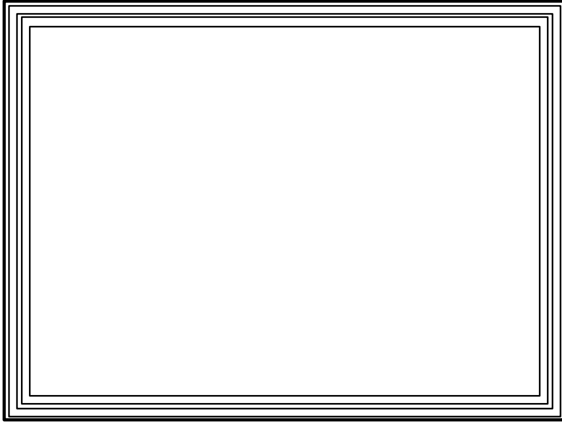

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CS 460/560

Computer Graphics

Professor Richard Eckert

Lecture # 14

March 21, 2001

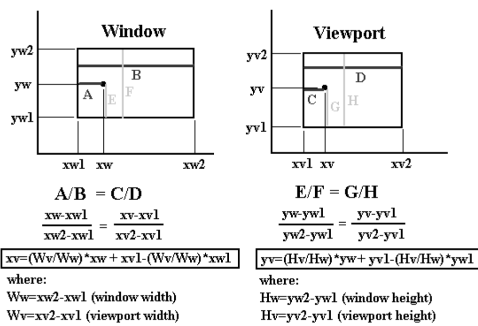
Lecture 14

A. Window to Viewport Transformation
B. Windows Mapping Modes
C. Windows DirectX
D. Clipping

2-D Viewing Transformation

- Convert from Window Coordinates to Viewport Coordinates
- (xw, yw) --> (xv,yv)
- Maps a world coordinate window to a screen coordinate viewport
- Window defined by: (xw1,yw1), (xw2,yw2)
- Viewport defined by: (xv1,yv1), (xv2,yv2)
- Basic idea is to maintain proportionality

Window to Viewport Transformation



Viewing Transformation Matrix

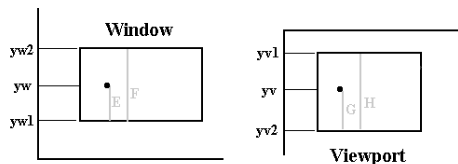
- Can cast into homogeneous matrix form:

```
        |xv|          |xw|
Pv  =   |yv|    Pw =  |yw|     Pv = Tv*Pw
        | 1|          | 1|

          | C1   0   C2 |
     Tv = | 0    C3  C4 |
          | 0    0   1  |
C1 = Wv/Ww,    C2 = xv1 - (Wv/Ww)*xw1
C3 = Hv/Hw,    C4 = yv1 - (Hv/Hw)*yw1
```

Be Careful with y-axis down

- y equation will be different!



Windows Mapping Modes

- Windows Implementation of the Viewing Transformation
- See: CS-360, CS-460/560 Notes and Sample Programs:

http://www.cs.binghamton.edu/~reckert/460/mapmodes.htm
http://www.cs.binghamton.edu/~reckert/360/class10.htm
http://www.cs.binghamton.edu/~reckert/360/mapmode1_cpp.htm
http://www.cs.binghamton.edu/~reckert/360/mapmode2_cpp.htm

Windows Mapping Modes

- Mapping Mode: a GDI Attribute
- Default DC coordinates: "Device Units"
  - For video screen: pixels
    - Origin at upper left corner of screen
  - For a printer: “dots”
    - Origin at upper left corner of printed page
- Problem--not all pixels/dots same size
  - So screen image can become a postage stamp on printer

Windows Mapping Modes

- Create logical system of units
- Windows maps output to real device
  - E.g., plot at 100,100 "logical millimeters”
  - Windows figures out where on screen
  - Not exact, but close

Windows Mapping Modes

MAPPING MODE	LOGICAL UNIT	X-AXIS	Y_AXIS
MM_TEXT	Pixel	Right	Down
MM_HIENGLISH	.001 inch	Right	Up
MM_LOENGLISH	.01 inch	Right	Up
MM_HIMETRIC	.01 mm	Right	Up
MM_LOMETRIC	.1 mm	Right	Up
MM_TWIPS	1/20 point=1/1440”	Right	Up
MM_ISOTROPIC	Arbitrary (x==y)	Selectable	
MM_ANISOTROPIC	Arbitrary (x!=y)	Selectable	

Changing the Mapping Mode

- pDC->SetMapMode(MAP_MODE);
- Maps logical to device coordinates
  - dc units: pixels, +x: right, +y: down
  - converts logical ("window") to device ("viewport") coordinates as follows

    xV = (xVExt/xWExt) * (xW - xWOrg) + xVOrg

    yV = (yVExt/yWext) * (yW - yWOrg) + yVOrg
- (xWOrg,yWOrg) and (xVOrg,yVOrg) are the origins of the window and viewport
- Both are (0,0) in the default device context

Moving Origins

- pDC->SetWindowOrg(x,y); // log. units
  - For x,y positive, think of this as moving the upper left-hand corner of the screen/paper up and right by (x,y) logical units
- pDC->SetVieportOrg(x,y); // device units--pixels
  - For x,y positive, think of this as moving the lower left-hand corner of the logical window down and right by (x,y) device units
- Both move the coordinate system origin to (x,y), but units of x,y are different

Variable Unit Mapping Modes

- Coordinate axes can have any size/orientation
- MM_ISOTROPIC-- x & y units must be same size
- MM_ANISOTROPIC -- different x and y units
- Set the X and Y scaling factors with:

  pDC->SetWindowExt (xWExt, yWExt);

  pDC->SetViewportExt (xVExt, yVExt);
- X scaling factor in going from Logical Coordinates to Device Coordinates = xVExt/xWExt
- Y scaling factor = yVExt/yWExt

Example 1

- Create coordinate system where each logical unit is two pixels:
  - twice the default device unit coordinates

```
pDC->SetMapMode (MM_ISOTROPIC);
pDC->SetWindowExt (1, 1);
pDC->SetViewportExt (2, 2);
```

Example 2

- Create coordinate system with y-axis up, each y-unit = 1/4 pixel; x-axis unchanged:

```
pDC->SetMapMode (MM_ANISOTROPIC);
pDC->SetWindowExt (1, -4);
pDC->SetViewportExt (1, 1);
```

Example 3

- Create coord system where client area is always 1000 units high & wide, y-axis up:

```
CSize size;
size = pDC->GetWindowExt (); // get client area size
  // returns size in default device units--here pixels
pDC->SetMapMode (MM_ANISOTROPIC);
pDC->SetWindowExt (1000, -1000);
pDC->SetViewportExt (size.cx, size.cy);
```

- Now (1000,1000) will always be at upper right edge of client area

DirectX and Windows Game Programming

- Game Programming
  - No "good" (fast) Windows games before 1995
  - Only DOS games for PCs--
    - Direct access to video memory permitted
    - Fast

Windows GDI

- Device independence
- Useful but slow functions
- No access to video hardware
- ==> High-speed games almost impossible

Demanding Requirements for High-resolution Animated Graphics

- 640 X 480 X 256-color ➔
  - 307,200 bytes
  - If background changes in each frame (e.g., flight simulator)
  - 307K bytes must be moved to screen
  - At least 15 times a second
  - Almost 5 Megabytes/second

- Also sprites move on a background
- Must be transferred one-by-one to screen memory too
- To avoid flicker--
  - Compose Scene in memory
  - Then transfer it to screen
    - ➔ twice as much data must be moved
  - GDI BitBlt() and StrecthBlt() can't cope with this task in real time

Microsoft Remedy (1995): the "Game SDK" (DirectX)

- A series of components called "COM objects"
  - COM: an object-oriented interface
  - Creating/using A COM interface closely resembles creating/using a C++ class

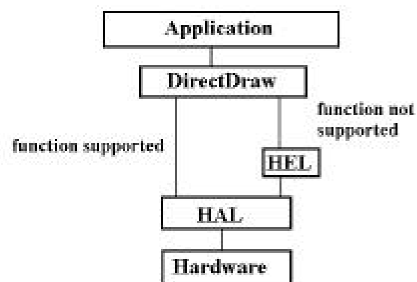
Some DirectX Components

- Direct Draw
- DirectSound
- DirectInput
- DirectPlay
- Direct3D

DirectDraw

- Provides direct control over the computer's video hardware
- Enables programs to quickly transfer graphics between memory and screen
- Takes advantage of hardware capabilities the video card
- Capabilities not available on video card are emulated in software

DirectDraw Hardware Access



DirectSound

- Provides device-independent way of directly accessing computer's sound card
- Enables programmer to add sound effects and music to games
- Can synchronize sound effects with events occurring on the screen
- Can handle 3D sound effects

DirectInput

- Provides for easy use of joystick/game controller devices
- Done in a device-independent way

DirectPlay

- Provides for implementation of multi-user games over a network or modem
- Transport-independent, protocol-independent, on-line-service-independent
- Allows Windows games to communicate with each other

Direct3D

- Provides optimized three-dimensional capabilities to Windows games
  - polygon modeling, 3D transformations, projections, clipping, surface properties, lighting, texturing, shadowing, hidden surface removal, animating
- Takes advantage of 3D acceleration hardware, if available
- No additional coding required of the game developer

DirectX games run under Windows

- Benefit from all the built-in Windows functionality
- Can use:
  - GDI graphics functions
  - All Windows user interface capabilities
  - All of fonts and other standard Windows drawing objects
  - In general, the entire Windows Win32 API

DirectDraw

- Main purpose:
  - To provide directly-accessible drawing "surfaces" in memory
  - To transfer drawing surfaces quickly to screen
- A surface:
  - A block of memory used for drawing
  - Separate surfaces used to hold each sprite in an animated scene
  - Another surface used to hold the background
  - Surfaces are composed into a final image
  - Which is transferred to the primary screen surface

Steps in Using DirectDraw in a Windows Program

- (Check the online help for details on the use of each DirectDraw function)

1. Call DirectDrawCreate () to create a DirectDraw object
2. Call the DirectDraw object's SetCooperativeLevel() member function==>
   Get control over screen and restrict access by other applications
3. Call DirectDraw object's SetDisplayMode() member function==>
   Set screen's resolution and color depth
4. Call DirectDraw object's CreateSurface() member ftn==>
   Create a primary surface object + one or more secondary surfaces (back buffers)
5. Call the primary DirectDrawSurface object's GetAttachedSurface() member function==>
   Get a pointer to a back buffer

6. Call the back buffer's DirectDrawSurface object's Lock() member function➔
   – Get a pointer to the back buffer surface's memory
7. Draw an image on the back buffer
   – **Access its memory directly**
8. Call the back buffer's DirectDrawSurface object's Unlock() member function==>
   – Tell DirectDraw that the program is done with the back buffer

9. Call the primary DirectDrawSurface object's Flip() member function➔
   - Swap surface memory associated with the primary surface and that of the next back buffer surface, thus displaying the newly-drawn image
10. When terminating the application, all direct draw objects should be removed by calling their Release() member functions

The lineminimum DirectDraw Example Application--

- Creates a 640 X 480 X 8-bit-color primary surface
- Draws 256 horizontal lines (using the current palette) on a back buffer surface
- Flips surfaces so the lines are displayed on screen
- A Win32 API program that has no menu
- Drawing action occurs in response to the user pressing the <F1> keyboard key

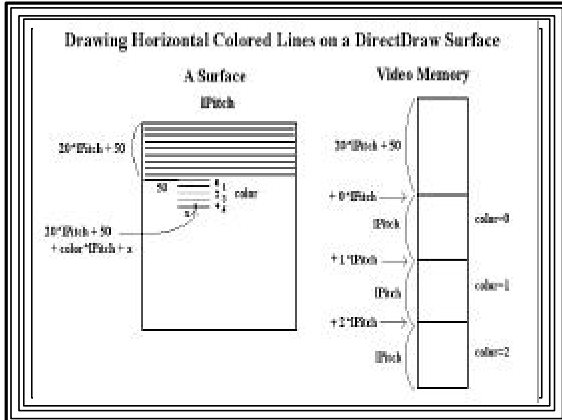
horlines.cpp

```
WinMain()
WndProc()
  VK_F1:
    Construct CDirDraw object (1-5)
    Invoke ChangeColor()
    Invoke Drawlines() (6-8)
    Call m_pPrimarySurface->flip() (9)
    Destructor gets rid of DirDraw objects (10)
```

CDirDraw Class (cdirdraw.cpp, .h)

```
Constructor()
Destructor()
Drawlines()
ChangeColor()
```

- The Program's CDirDraw class:
  – Specification in cdirdraw.h
  – Implementation in cdirdraw.cpp
    - Does most of the work in this example
    - Defines a pointer to a DirectDraw object and two pointers to DirectDraw surfaces
    - Its constructor performs steps 1 through 5 (above)
    - Its destructor performs step 10
    - Member functions ChangeColor() & DrawLines() do rest (steps 6 through 8)



- <ESC> key terminates the application
- Application keeps track of/displays time required to draw lines on back buffer
- And time required for the surface switch
  - Uses GDI TextOut() to do the display
- Program uses DirectDraw member functions in the simplest ways possible
- A robust application would do extensive error checking after most of function calls (Refer to the references.)

DirectX and lineminimum Details

- See following CS-360 Web Pages:
- Course Notes
- Class 4x--DirectX and Windows Game Programming

http://www.cs.binghamton.edu/~reckert/360/class4x.htm

- Sample Programs
- Example 4-6: lineminimum DirectX Example

http://www.cs.binghamton.edu/~reckert/360/horlines_cpp.htm
http://www.cs.binghamton.edu/~reckert/360/cdirdraw_cpp.htm
http://www.cs.binghamton.edu/~reckert/360/cdirdraw_h.htm