ECE291

Lecture 12

Mode 13h Graphics

Lecture outline

- Color theory
- Video Hardware
- Mode 13h
- Graphics File Formats

Color theory

- TV's, Computer Monitors, Projectors… It's all Red, Green, Blue
- Why RGB? These are the primary colors for visible light. You can get all the colors by mixing them.
- Red + Green = Yellow
- Green + Blue = Cyan
- Blue + Red = Purple

Color Theory - Biology

- How can mixing a Low Frequency with High Frequency make Really High Frequency?
- It can't. Remember your ECE 210. It's all biological.
- Our eyes have red, green, and blue sensors. These are the colors we can see best (ie, the frequencies for which we have color receptors)
- The people who invented color photography and color TV used this fact.

Color Theory - Biology

- If three-eyed aliens with different color receptors visited us, they'd "see" the same three frequencies coming from the monitor, but they wouldn't be able to see any pictures.
- The same goes for your dog that wonders why you spend hours looking at a blank screen.

Full Color Images

- Each pixel has a Red, Green, and Blue value.
- 24-bit color means 1 red byte, 1 green byte, 1 blue byte. Each determines the color intensity (0 = none, 255 = full) of their respective color components.
- 16-bit color means 5 bits red, 5 bits green, 5 bits blue. The extra bit is sometimes a green bit depending on the system.
- Full color is when we use a given number of bits to specify the intensity of each color component.

24-bit Full Color Images

- 24-bit color allows 256 different intensities for each color component. This allows for 2^{24} or 16,777,216 different colors.
- That's way more than our eyes can distinguish.
- This 24-bit color is sometimes called **Full** or **True** color.
- True color requires 3 bytes for every pixel.

16-bit Full Color Images

- 16-bit color allows 32 different intensities for each color component. This allows for 2^{15} or 32,768 different colors (assuming 5 bits green)
- Not quite as good as True color, 16-bit color is also referred to as High color.
- High color requires 2 bytes for every pixel.

Full Color Images

- Positives of high and true color images
  - More colors means higher quality pictures
  - Easier to do image manipulation (math)
    - Make everything a little redder
    - Blur an image by averaging RGB values of adjacent pixels
- Negatives of high and true color images
  - Take up a lot more memory

    Ex: A 320x200 pixel image with 24-bit color needs

    320 x 200 x 3 = 192,000 bytes of memory

Color Palettes

- While we'd like to do everything in full color, in real mode we need to reduce the amount of memory our images use.
- The **color palette** contains the 3-byte RGB values of 256 different colors.
- The image data is then just a bunch of indexes into this palette. It's a look-up table!

Color Palettes

- Positives of palettes
  - Less memory and bandwidth needed to store and move pictures
  - You can do some cool stuff with palettes
    - Invisible pixels – assign one palette entry to be “clear” and when you’re copying one image over another, don’t copy the “clear” pixels.
    - You can cycle the palette for 60’s psychedelic effects.
    - You can fade out a screen just by subtracting from each entry in the palette table until they’re all zero

Color Palettes

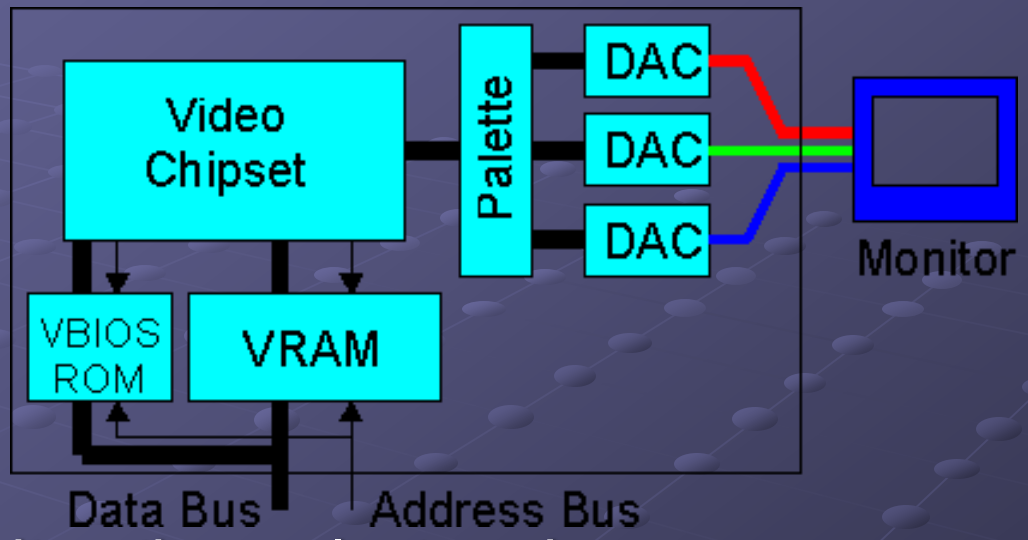
- Negatives of palettes
  - Fewer colors (at most 256) mean lower quality pictures
  - Harder to do manipulation
    - Average blurring is harder because new color isn't in palette
  - All "real" images come in full color and have to be converted
    - This is hard because you have to choose a good palette
    - For each "full color" pixel, find closest palette entry
  - When you put images together, they share same palette

Text Mode Video Revisited

- Text mode video is kind of like a form of palette
- Each ASCII byte is an index into a font table with a bitmap for each character
- Each Mode Byte is an index into a type of palette
- Or you can think of the mode byte as 3-bit full color (kind of)

Video Hardware

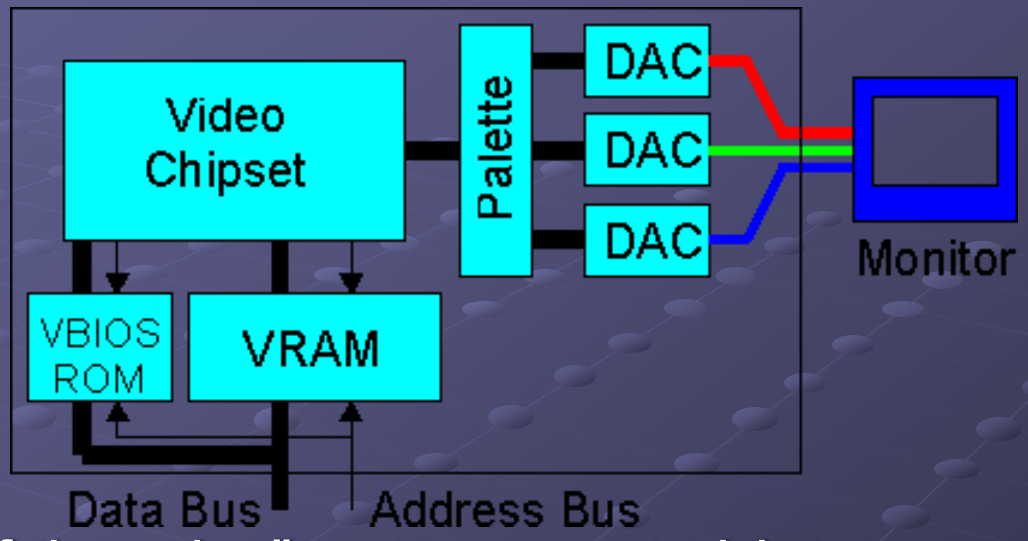
- You've got a chunk of memory
- You write to the memory through memory mapped I/O (MP3)



- In a analog RGB monitor, three electron beams sweep across all rows 60 to 85 times a second to zap the phosphor elements to make them glow
- The video card adjusts the intensity of the three electron beams in real time as they are sweeping to correspond to the intensities specified in the VRAM

Video Hardware

- To do this, the video card reads out a whole row of RGB values in the VRAM and shifts them "out" in a big shift register.



- The byte that "falls off the edge" gets converted into an intensity for the electron beam.
- With a palette, there is an additional step. Before data shifts out, it looks up the "real" RGB value in palette memory.

Mode 13h

- Mode 13h is a 320 x 200 x 256-color graphics display mode that was very popular for DOS programming due to its relatively high number of colors (256 vs 16 for other VGA modes) and simple addressing.
- 320 x 200 = 64000 pixels. With 1 byte per pixel this easily fits in a single real-mode segment.
- It's linear just like text mode. The pixels increase in memory as you go from left to right, while each row immediately follows the previous one.

Offset = row*320 + col

Mode 13h - How to get there

- The following instructions get you into Mode 13h video

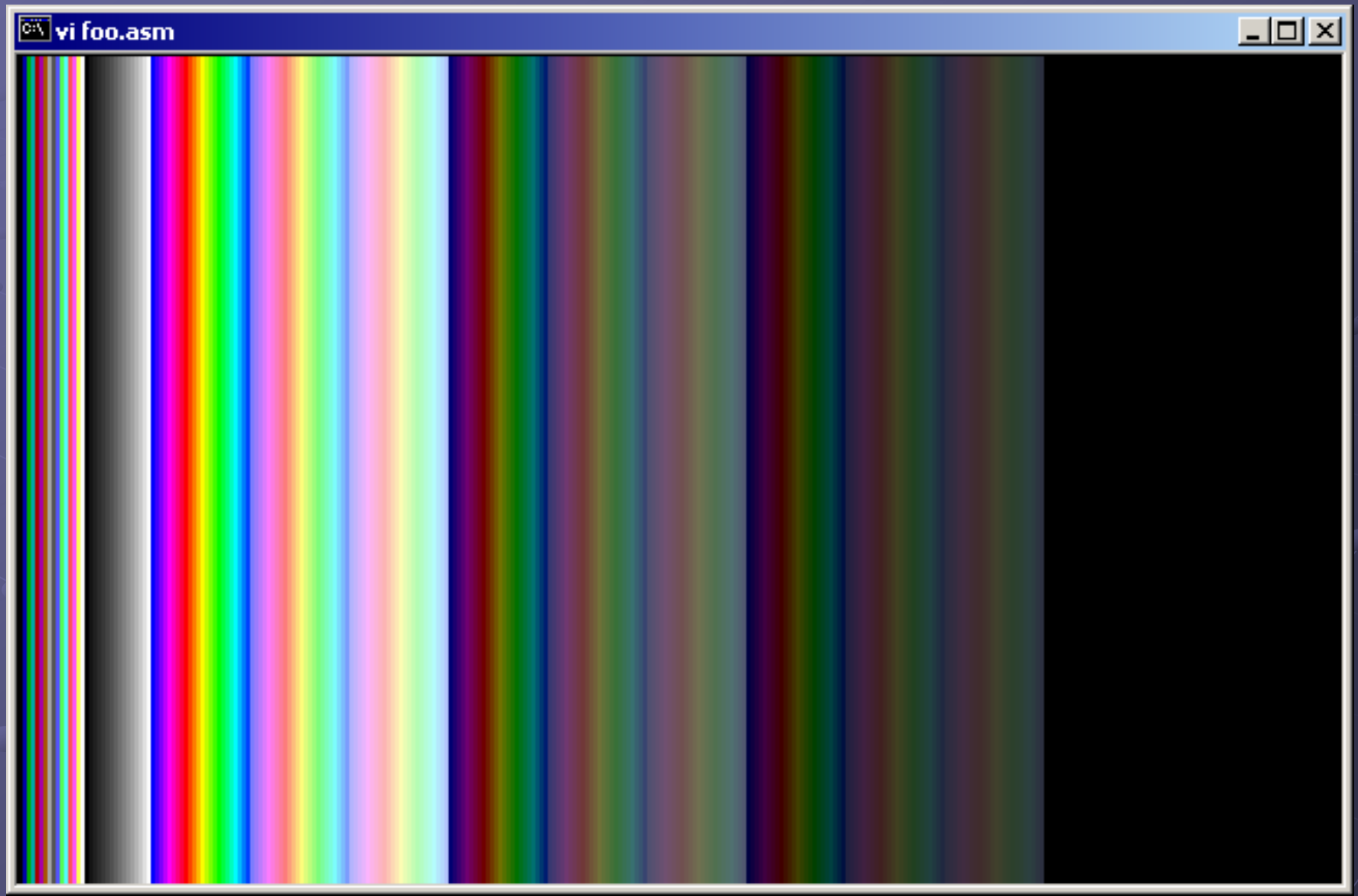
```
mov ah, 0       ; int 10h's set mode subfunction
mov al, 13h     ; The aptly named Mode 13h
int 10h         ; Call the Video BIOS interrupt
```

Mode 13h
How to draw a pixel

- The following instructions draw a pixel on the screen

```
VidGrSeg equ        0A000h
Location dw         (200/2)*320+(320/2)          ; Center
Color db 98         ; Some random palette index
mov ax, VidGrSeg
mov es, ax          ; Use extra segment to address VRAM
mov bx, [Location]  ; Offset to center of screen
mov al, [Color]     ; Palette Entry Number
mov [es:bx], al     ; Write it to the screen
```

Mode 13h
The Default Palette



Mode 13h
How to change the palette

- Method 1: Load an entire palette
  - Write 0 to port 3C7h
  - Write red, green, blue bytes to port 3C9h for all 256 colors
- Method 2: Change just one palette entry using VBIOS call
  - BX = Palette Number (0 – 255)
  - CH = Green (0 – 63)
  - CL = Blue (0 – 63)
  - DH = Red (0 – 63)
  - AX = 1010h ; Set VGA Palette Registers command
  - INT 10h ; vBIOS call

Mode 13h
How to change the palette

```
; Change a palette entry to light purple
Red    db      39
Green  db      0
Blue   db      63
Mov    bx, 0   ; changing palette entry 0
Mov    ch, [Green]
Mov    cl, [Blue]
Mov    dh, [Red]
Mov    ax, 1010h
Int    10h
```

Graphics File Formats

- Raster Formats
  - Arrays of pixels (what we've been talking about)
  - Raw pixels (.bmp)
  - Run-Length encoding (.pcx)
  - LZW encoding (.gif)
  - Transform encoding (.jpg)
  - Deflate (zip) compression (.png)

Graphics File Formats

- Vector Formats
  - Like PostScript or CorelDraw
  - A vector file might have something like:
    - "Draw line from (24, 56) to (87, 12)"
    - "Here's what an 'A' looks like…."
    - "Not draw an 'A' at (75, 96)"
  - Eventually converte to raster format by using a rasterizer
    - Printers are very high resolution rasterizers (for example)

Graphics File Formats

- Included in image files…
  - Header: Most file formats start out with some kind of info about the image. For graphics files this info could be:
    - Size (horizontal and vertical pixels)
    - Color depth (bits per pixel)
    - Version (makes life difficult…GIF89A, GIF97A, …)
    - Compression Technique
  - Palette: If you're not using true color, you must include a palette for the image in the image file
  - Data: Raw or compressed, raster or vector information.

Graphics File Formats
Bitmap (.bmp)

- Included in image files…
  - Header: Most file formats start out with some kind of info about the image. For graphics files this info could be:
    - Size (horizontal and vertical pixels)
    - Color depth (bits per pixel)
    - Version (makes like difficult…GIF89A, GIF97A, …)
    - Compression Technique
  - Palette: If you're not using true color, you must include the palette for the image in the image file
  - Data: Raw or compressed, raster or vector information.

Graphics File Formats

Discussion of various graphics file formats. Go to

http://courses.ece.uiuc.edu/ece291/lecture/lockwood/l15.html

Announcement

Sandia National Labs Visit (HKN)

For more information visit

www.iansteiner.com/sandia.html