

graphics and monitors

digitization of images

- pixels

- bits per pixel

crt monitor vs. lcd monitor

monitor features

- viewable image (smaller on crt due to bezel)

- dot pitch - space between pixels, sometimes width of pixels

- flat screen vs. flat panel

- supported resolutions - lcd has native

- supported refresh rates (crt)

- response rate (lcd)

- heat and electricity usage

price comparison

Session: Hardware
Topic: Monitors

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Computer Images

- Real images (photographs, vision) are analog
- Must digitize for use by a computer
- Break up images into grid of dots (each becomes a sample)
- Use some number of bits to represent the color of each dot
- A single image dot is a "pixel" ("picture element")

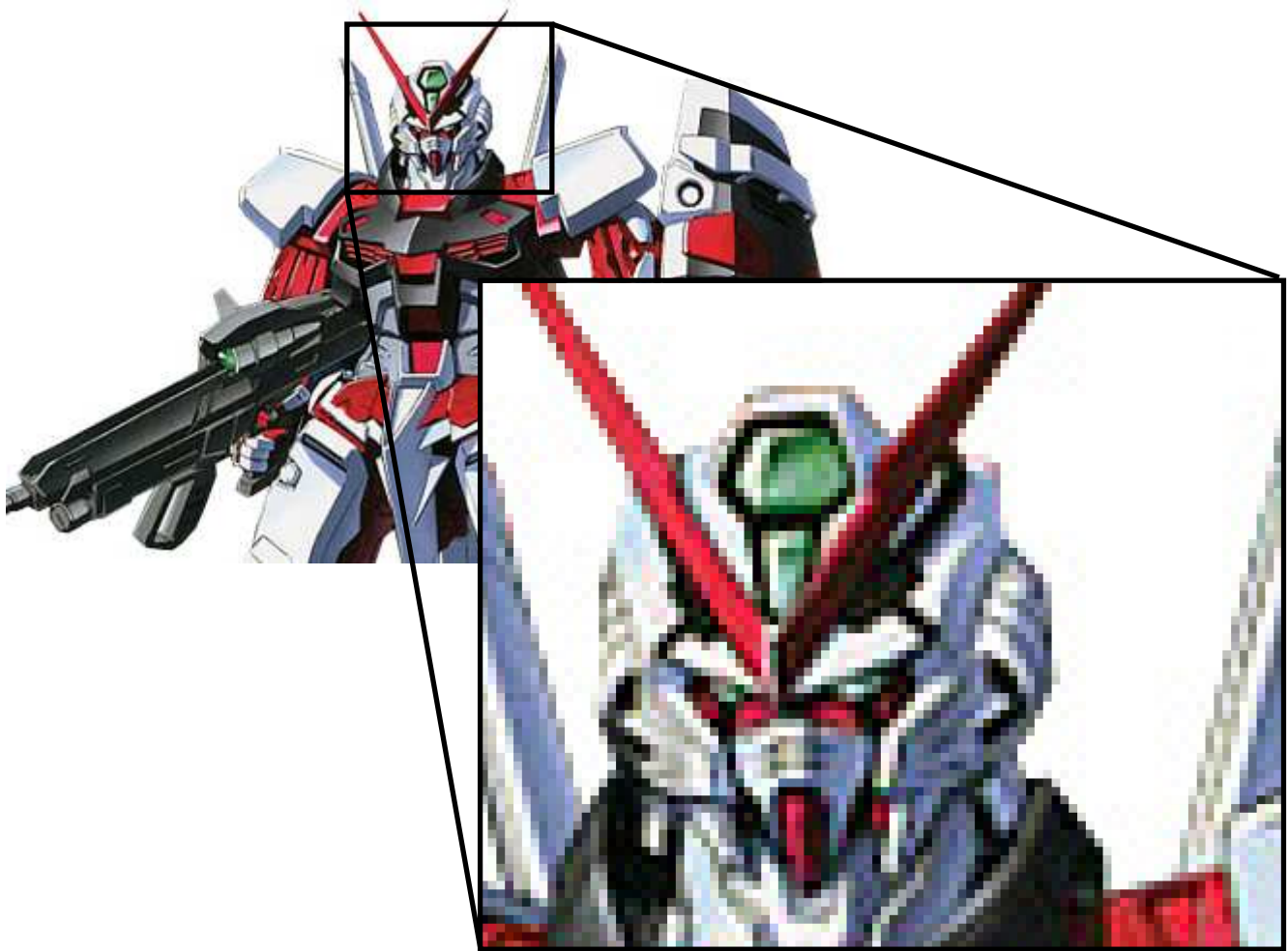


Image Resolution

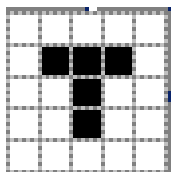
- Also "dimensions"
- Number of pixels that make up the image
- Typically rectangular and given in width and height
- Resolutions can be anything, but some common resolutions are:

Width	Height	Total Pixels	Aspect Ratio
640	480	307,200	4:3 (standard)
800	600	480,000	4:3
1024	768	786,432	4:3
1280	1024	1,310,720	5:4 *
1280	768	983,040	5:3 * (widescreen)
1600	1200	1,920,000	4:3
1920	1200	2,304,000	16:10 * (widescreen)

* True "widescreen" is (16 x 9), (5 x 4) is just odd

Color Depth

- Also "bits per pixel" or "bpp"
- Number of bits used for each pixel of a digitized image
- In the simplest case of black and white, can use a single bit (0 for white, 1 for black)



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0	0	0	0	0	0	1	1	1	0
0	0	1	0	0	0	0	1	0	0
0	0	0	0	0					

- For pixels of multiple colors, must use more bits per pixel

BMP File Format

bpp	Number of possible colors
1-bit	2
4-bit	16
8-bit	256
24-bit	1,677,216 (256x256x256)

16-bit (not BMP standard)	32,768
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- BMP uses RGB format for interpreting the bits in a 24-bit pixel (essentially three 8-bit colors mixed)
- In additive color formats
- The bits are divided into three sections, representing the amount of red, green, and blue in the color

	Red (8 bits)	Green (8 bits)	Blue (8 bits)
24-bit pixel	1111 1111	1000 0101	0000 0000

- BMP file starts with some header information
- Then simply a series of 24-bit sections, one for each pixel

Example

- Given a 640 x 480 pixel image with an 8 bpp bit depth:

$$\begin{aligned} \textit{Total Size} &= 640 \times 480 \textit{ pixels} \times 8 \textit{ bits} / \textit{pixel} \\ &= 640 \times 480 \times 8 \textit{ bits} \\ &= 640 \times 480 \textit{ Bytes} \\ &= 307,200 \textit{ Bytes} = 300 \textit{ KB} \end{aligned}$$

- Can view individual pixels of an image using Microsoft Windows "Paint" program

Monitor Technologies

CRT (Cathode Ray Tube)

- Uses a large glass "tube" similar to older televisions
- An electron beam shines through a metal shadow mask, a screen with holes representing pixels

LCD (Liquid Crystal Display)

- Uses LCD like in a digital watch
- Screen is composed of a grid of LCDs, each representing a pixel
- Each pixel is composed of three single LCDs (one red, one green, one blue)
- Active matrix technology - uses TFT (Thin Film Transistor) to make really nice LCDs



Monitor Features

Flat Screen vs. Flat Panel

- CRT tubes are traditionally curved glass
- LCD monitors are called "Flat Panel"
- Newer CRT monitors with flat glass tubes have been called "Flat Screen"
- Due to complaints the new term "Flat Tube" has been used

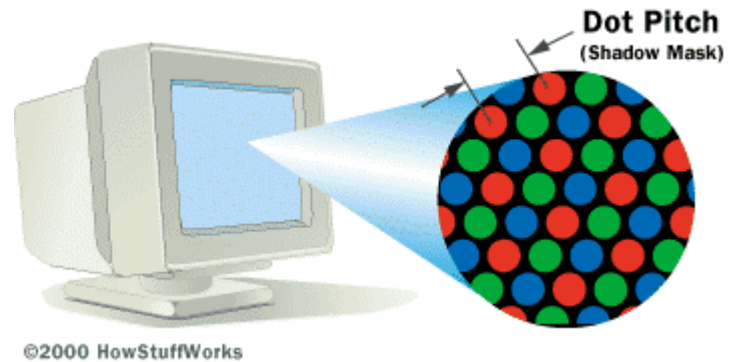
Screen Size

- Listed as diagonal distance from corner to corner
- For CRT monitors size is actually larger than visible glass, due to overlap of screen bezel
- "Viewable Image" has been used to describe actual visible glass
- 17" CRT monitors typically only have 16" viewable images
- For LCD monitors the screen size is the same as the viewable size



Dot Pitch

- For CRT monitors refers to the distance between holes in the shadow mask
- Also described as width of holes or distance between edges of holes
- For LCD monitors refers to the distance between same color LCDs in neighboring pixels (red, green or blue)
- Smaller dot pitch (measured in millimeters) allows for better detail



	CRT	LCD
Good	0.25 mm	0.264 mm
Minimum acceptable	0.28 mm	

Resolutions

- CRT monitors have a range of "Supported Resolutions" that the monitor can be set to display in (implying a maximum resolution)
- Displaying an image file with a larger resolution than the monitor is running will result in only part of the image being visible
- Displaying higher resolutions results in *smaller* objects on the screen, but allows for better detail as well as more objects to fit on the screen
- LCD monitors have a "Native Resolution" which is the actual number of LCDs in the grid
- LCD monitors cannot display higher than their native resolution, and lower resolutions display really fuzzy
- Individual LCDs can break, resulting in "dead pixels"

Given a CRT monitor displaying in 1280 x 1024 resolution

- Two 640 x 480 image files could be displayed side by side
- Four 640 x 480 image files could be displayed in a grid with a little extra room top and bottom
- If you display a single 1600 x 1200 image only a portion (1280 x 1024) would be visible at any one time
- If you change the monitor settings to display at a lower resolution
 1. Objects will appear larger
 2. Less will fit on the screen
 3. The image quality will still be good (or even better)

Given an LCD monitor with a native resolution of 1024 x 768

- It could not be run in any higher resolution
- It would look fuzzy at lower resolutions

Refresh Rates

- The electron gun in a CRT tube repeatedly travels across the entire screen
- CRT monitors have a range of supported "Refresh Rates" (Hz) of how often the electron gun can refresh the entire screen
- Low refresh rates (60 Hz and less) result in screen "flicker" and can cause headaches and eye strain
- 70 Hz - 85 Hz are good values for avoiding flicker
- Typically at higher resolutions monitors are capable of lower and lower refresh rates

Response Time

- LCD monitors technically do not have refresh rates since all LCD pixels receive electricity simultaneously (almost all have reported refresh rates of 60 Hz)
- Instead, LCDs take time to respond to turning on and off, or changing colors (in milliseconds)
- Higher "response time" (slower) results in "ghosting" or trailing of moving images
- For graphically intensive applications the minimum response time to avoid ghosting is 12 ms
- 8 ms is very good but expensive

Heat and Electricity

- The electron gun and circuitry in a CRT monitor uses high amounts of electricity and generates high amounts of heat (can cause brownouts if plugged into a small UPS)
- Electricity usage and heat is much lower in an LCD monitor
- CRT monitors consume 100 W on average for a 19" monitor, while a 19" LCD monitor averages 50-60 W

Many More Features

- Viewing Angle (LCD)
- Aspect Ratio (some monitors are now widescreen)
- Contrast Ratio
- Connection types (VGA, DVI, HDMI)

Microsoft Windows

- To set your display resolution and refresh rate right-click on the desktop and select "Properties"
- **BEWARE** - using resolutions and refresh rates not supported by your monitor will result in damage

Advantages

CRT	LCD
Less expensive	Require less power
Better color representation, better black level	Thinner and lighter weight
More responsive, less blurring and ghosting	Less refresh rate issues, Less flicker and eye strain
Multiple resolutions	
More rugged, no dead pixels	

From "computer.howstuffworks.com"

Viewsonic 19" CRT Monitor (E90FB-4)

- 18" Viewable Screen (shysters)
- 1792 x 1344 maximum resolution (at 65 Hz - shysters)
- 1280 x 1024 at 80 Hz
- Dot Pitch: 0.25 mm
- Weight: 39.7 lbs
- Power Consumption: < 100 W
- \$218



Sony 19" Flat-Panel LCD Monitor (SDM-HS95P/S)

- 19" Viewable Screen (shysters)
- 1280 x 1024 native resolution
- (Probably 1024 x 768 at 70 - 75 Hz)
- Dot Pitch: 0.294 mm
- Response Time: 12 ms
- Weight: 13.2 lbs
- Power Consumption: 60 W
- \$610

