Evolution from Vector to Raster Graphics

History:

- **Vector**
  - Drive a oscilloscope by supplying x and y deflections
  - Calligraphic or line drawing display ('50s)
  - Phospors decay, thus must be refreshed: *display list*
  - CRT memory!
- **Raster**
  - Motivated by television ('30s)
  - Refresh monitor from framebuffer ('70s)
  - Advantage: images very general (tv,text,movies)
  - Disadvantage: original cost of memory, low-level

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Raster Graphics

ras.ter \'ras-t<e>r\ n (ca. 1934)

[G, fr. L raster, rastrum rake, fr. radere to scrape]

:a scan pattern (as of the electron beam in a cathode-ray tube) in which an area is scanned from side to side in lines from top to bottom;

:a pattern of closely spaced rows of dots that form the image on a cathode-ray tube (as of a television or computer display)

From *Websters*

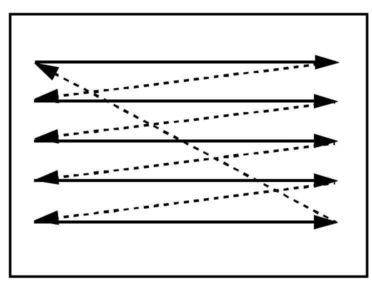

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Image Resolution

Three aspects:

- Spatial resolution
  - Physical limits: controllable "pixel" size
  - Human limits: photoreceptor density + optics
- Color and intensity resolution
  - Physical limits: color "pigments", 1-bit vs n-bit tones
  - Human limits: brightness and color sensitivity
- Temporal resolution
  - Physical limits: film transport, channel bandwidth
  - Human limits: neurons, flicker fusion rate>30Hz

World is continuous, digital media is discrete

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Image Resolutions in Practice

NTSC TV	640x480x8b	1/4 MB
Bitmapped display	960x1152x1b	.1 MB
Color workstation	1280x1024x24b	5 MB
Laser printed page		
300dpi	(8.5"x300)(11"x300)	1.05 MB
2400dpi	(8.5"x2400)(11"x2400)	~64 MB
Film (line pairs/mm)		
35mm slide (ASA 25)	35mm x 125lp/mm = 4375	
	4500 x 3000 x 3 x 12b	~64 MB

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Aspect Ratio

Frame aspect ratio (FAR) = horizontal/vertical size

TV	**4:3**	
HDTV	**16:9**	
Page	**8.5:11 ~ 3/4**	
35mm	**3:2**	
Panavision	**2.35:1**	**(2:1 anamorphic)**
Vistavision	**2.35:1**	**(1.5 anamorphic)**

Pixel aspect ratio (PAR) = FAR hres/vres

Nuisance in graphics if not 1

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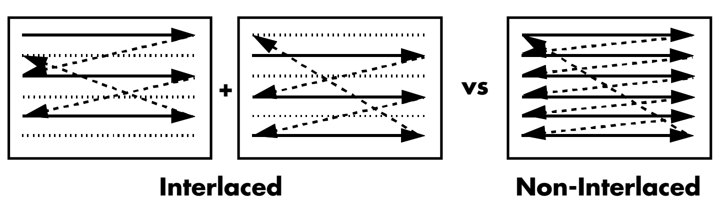
Refresh Rates and Bandwidth

Frames per second (FPS)

Film (double framed)	**24 FPS**
TV (interlaced)	**30 FPS x 1/4 = 8 MB/s**
Workstation (non-interlaced)	**~70 FPS x 5 = 350 MB/s**



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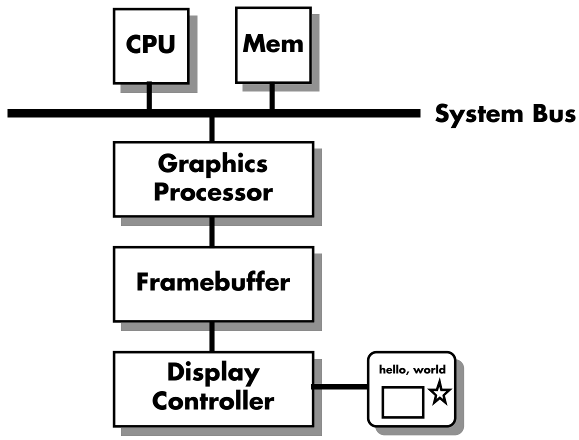
Raster Graphics System Architecture



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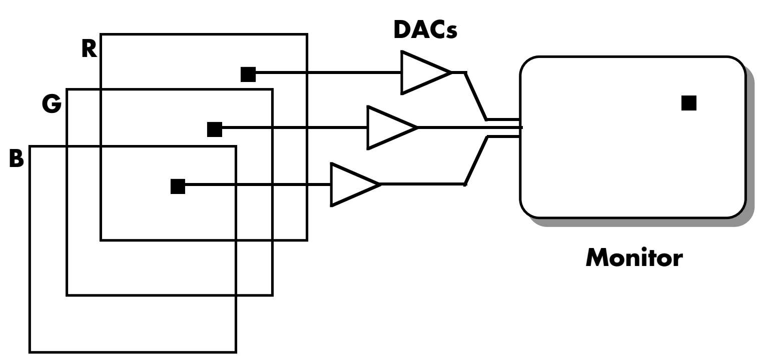
RGB Framebuffer



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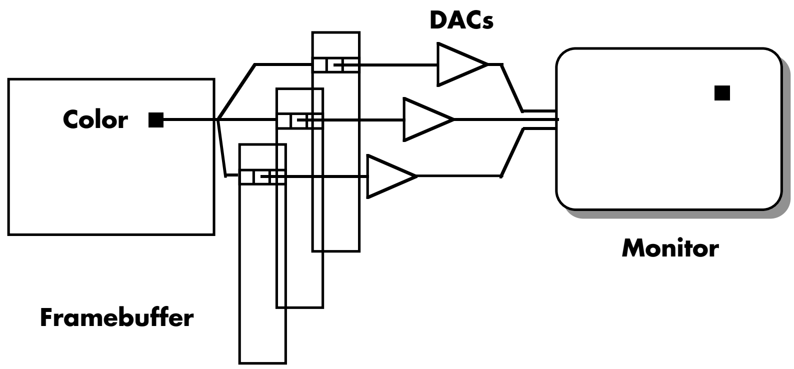
Color Index Framebuffer



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Color Mapping

Applications

- Apply function: gamma, invert, solarize
- Pseudocolor: blue to yellow to red ramp
- Animation by numbers, cycling
- Bit-plane extraction
- ...

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Buffers

- Single and double buffering: Front and Back
- Z-Buffer
- Texture Map Buffer
- Window ID Buffer
- Accumulation Buffer
- Stencil Buffer
- Stereo: Left and Right

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