University of British Columbia

CPSC 414 Computer Graphics

Displays, Devices

Week 12, Mon 17 Nov 2003

News

- my office hours in lab from now on
  - 10:30-11:30 today

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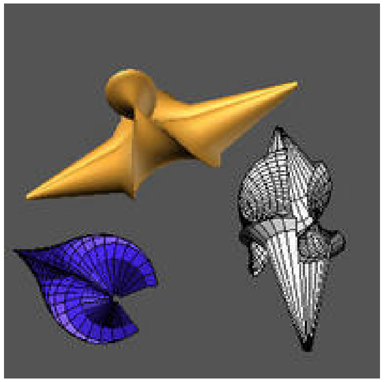
CPSC 414 Computer Graphics

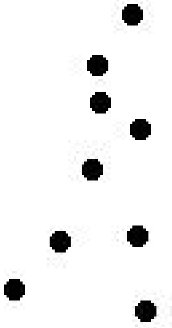
InfoVis finish

Motion: Clarify Structure

- navigation
  - rotate/translate/zoom



- object recognition
  - moving lights at joints [Johnson 1973]
    [www.psy.vanderbilt.edu/faculty/blake/biowalker.gif]



- animated transitions
  - jump increases cognitive load
  - smooth transition from one state to next
  - maintain object constancy

Outline

- information visualization motivation
- designing for humans
- information visualization techniques
- future directions

Scaling to Huge Datasets

- data explosion
  - sensors
    - Human Genome Project
    - Sloan Digital Sky Survey
  - simulation
    - Accelerated Strategic Computing Initiative
    - microprocessor design
  - logging
    - long distance telephony backbone
    - Web traffic: Google, Akamai

Scaling to Display Resolution

- interactivity + resolution of paper
  – combine physical navigation (get closer by moving head, walking) with virtual navigation
  – don’t get lost with physical navigation

InfoVis Opportunities

- term 2 course
  - 533C: Information Visualization
  - undergrads by consent of instructor

- research job opportunity
  - hiring co-op student in January
  - 414 experience strongly desired
  - talk to me soon if interested

Past: Never Enough Pixels

- visualization is pixel-bound
  - vs. CPU-bound, I/O-bound, render-bound
  - running out of pixels is chief bottleneck
- pixels as precious resource
  - like CPU cycles used to be
  - evolution: batch, command line, WIMP, infovis
- why?

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Displays, Hardware

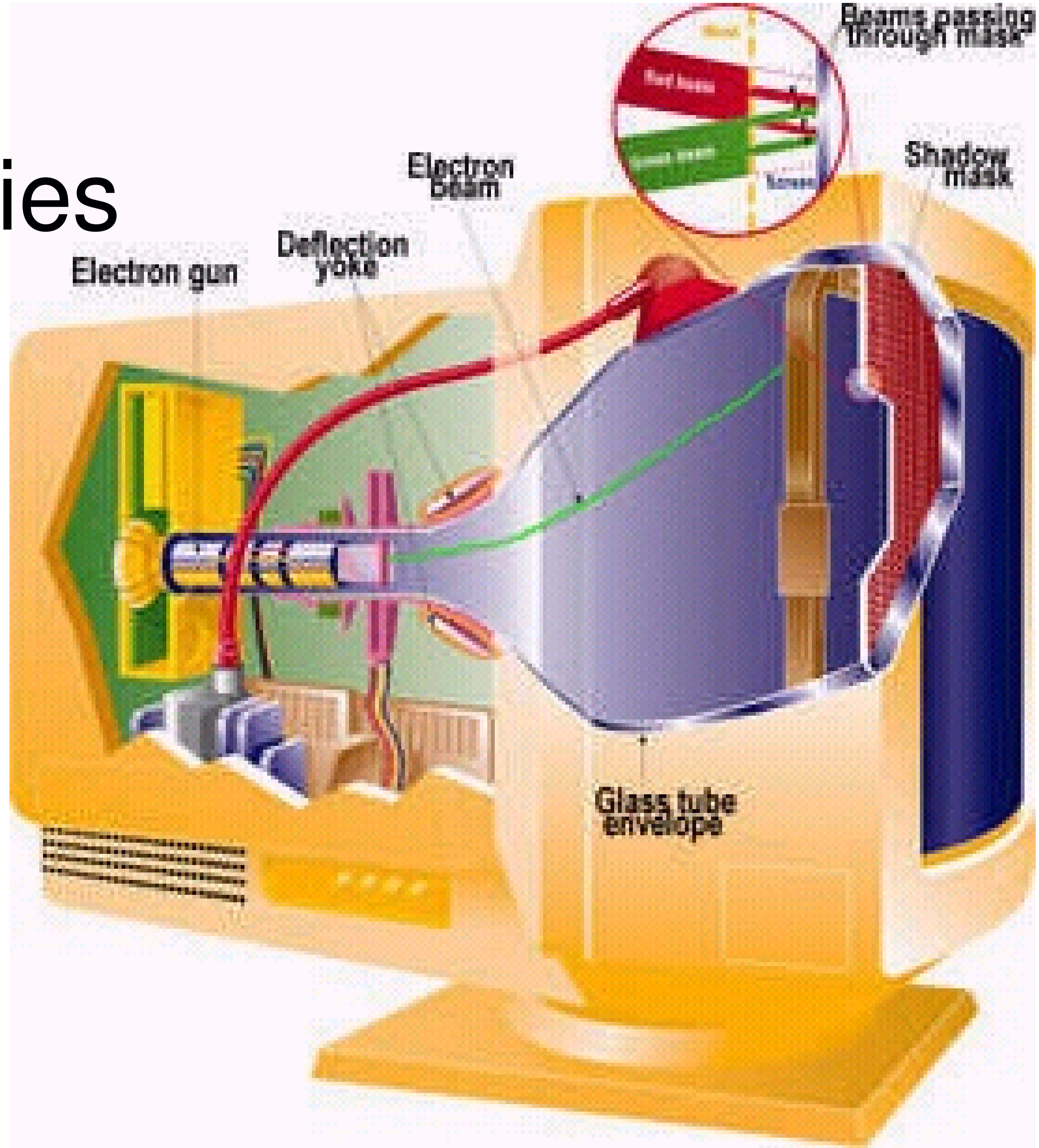
Past: No Moore's Law for Displays

year	1984	1994	2004
size	640x480	1024x1280	1600x1200
Mpixels	.3	1.3	1.9
ML predict		(10)	(300)

- CRT size, weight
  - sits on table: keyboard, mouse

Display Technologies

- CRTs



Display Technologies

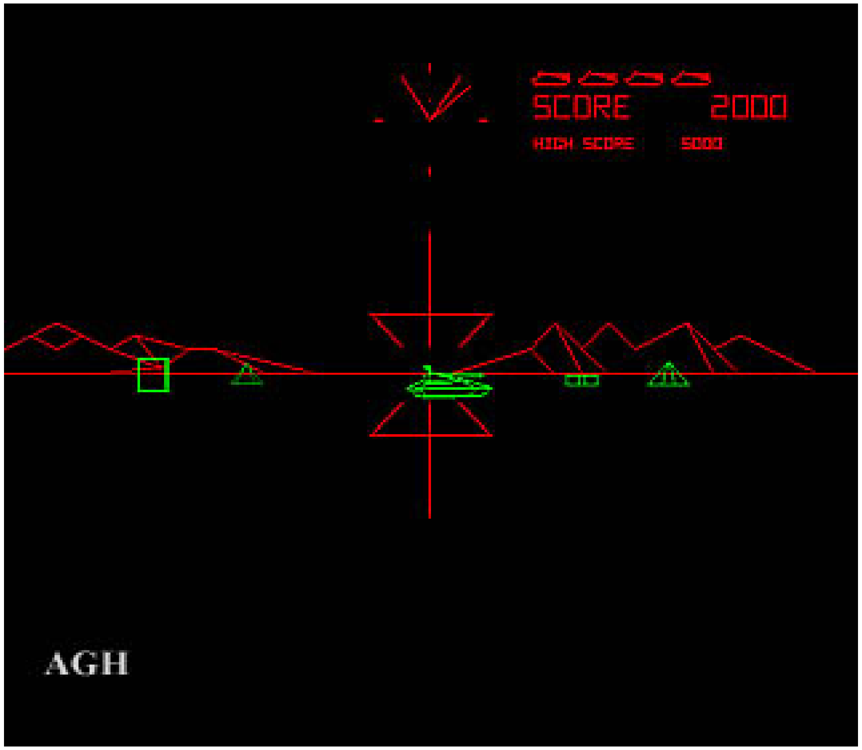
- Cathode Ray Tubes (CRTs)
  – most common display device today
  – evacuated glass bottle
  – extremely high voltage
  – heating element (filament)
  – electrons pulled towards anode focusing cylinder
  – vertical and horizontal deflection plates
  – beam strikes phosphor coating on front of tube

Electron Gun

- contains filament that, when heated, emits stream of electrons
- electrons focused with electromagnet into sharp beam and directed to a specific point of the face of picture tube
- front surface of the picture tube coated with small phosphor dots
- when beam hits a phosphor dot
  - glows with a brightness proportional to strength of beam and how often it is excited by beam

Vector Displays

– anybody remember *Battlezone*? *Tempest*?

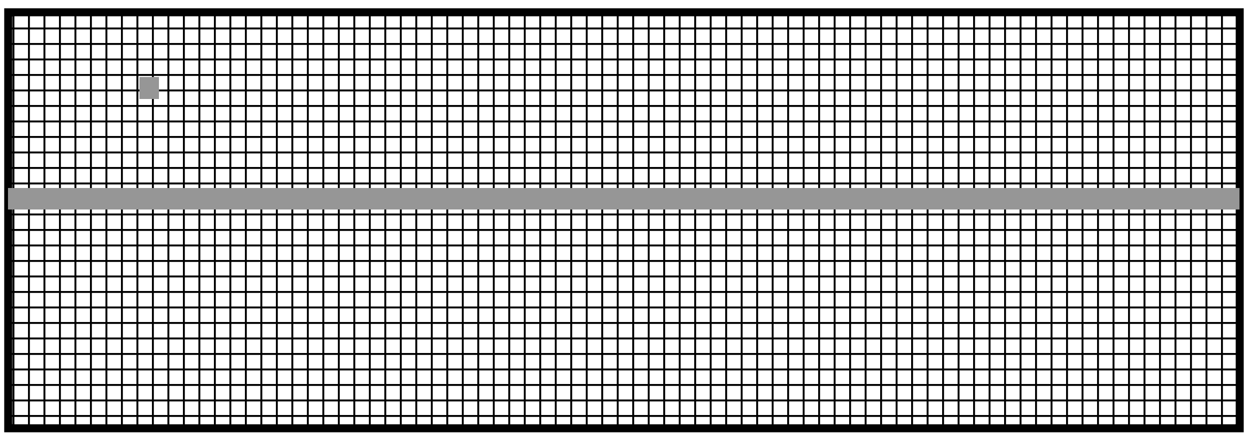


Vector Displays

- early computer displays
  - basically an oscilloscope
  - control X,Y with vertical/horizontal plate voltage
  - often used intensity as Z
- cons
  - just does wireframe
  - visible flicker in complex scenes

Raster Displays

- raster: a rectangular array of points or dots
  - pixel: one dot or picture element of the raster
  - scan line: a row of pixels



Raster Displays

- black and white television
  - an oscilloscope with a fixed scan pattern: left to right, top to bottom
  - to paint the screen, computer needs to synchronize with scanning pattern of raster
    - solution: special framebuffer memory to buffer image with scan-out synchronous to the raster

Phosphors

- flourescence: light emitted while the phospher is being struck by electrons
- phospherescence: light emitted once the electron beam is removed
- persistence: time from removal of the excitation to moment when phospherescence has decayed to 10% of the initial light output

Raster Displays

- frame must be "refreshed" to draw new images
- as new pixels are struck by electron beam, others are decaying
- electron beam must hit all pixels frequently to eliminate flicker
- critical fusion frequency
  - typically 60 times/sec
  - varies with intensity, individuals, phosphor persistence, lighting...

Interlaced Scanning

– assume can only scan 30 times / second
– to reduce flicker, divide frame into two "fields" of odd and even lines

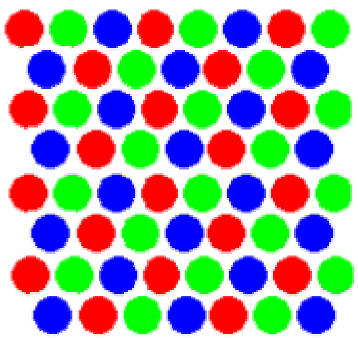
1/30 Sec		1/30 Sec	
1/60 Sec	1/60 Sec	1/60 Sec	1/60 Sec
Field 1	Field 2	Field 1	Field 2
Frame		Frame	

Scanning

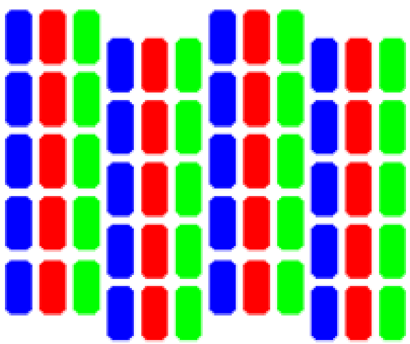
- left to right, top to bottom
  - Vertical Sync Pulse: signals the start of the next field
  - Vertical Retrace: time needed to get from the bottom of the current field to the top of the next field
  - Horizontal Sync Pulse: signals the start of the new scan line
  - Horizontal Retrace: time needed to get from the end of the current scan line to the start of the next scan line

Color CRTs

- color CRTs much more complicated
  - requires manufacturing very precise geometry
  - uses a pattern of color phosphors on the screen:



Delta electron gun arrangement

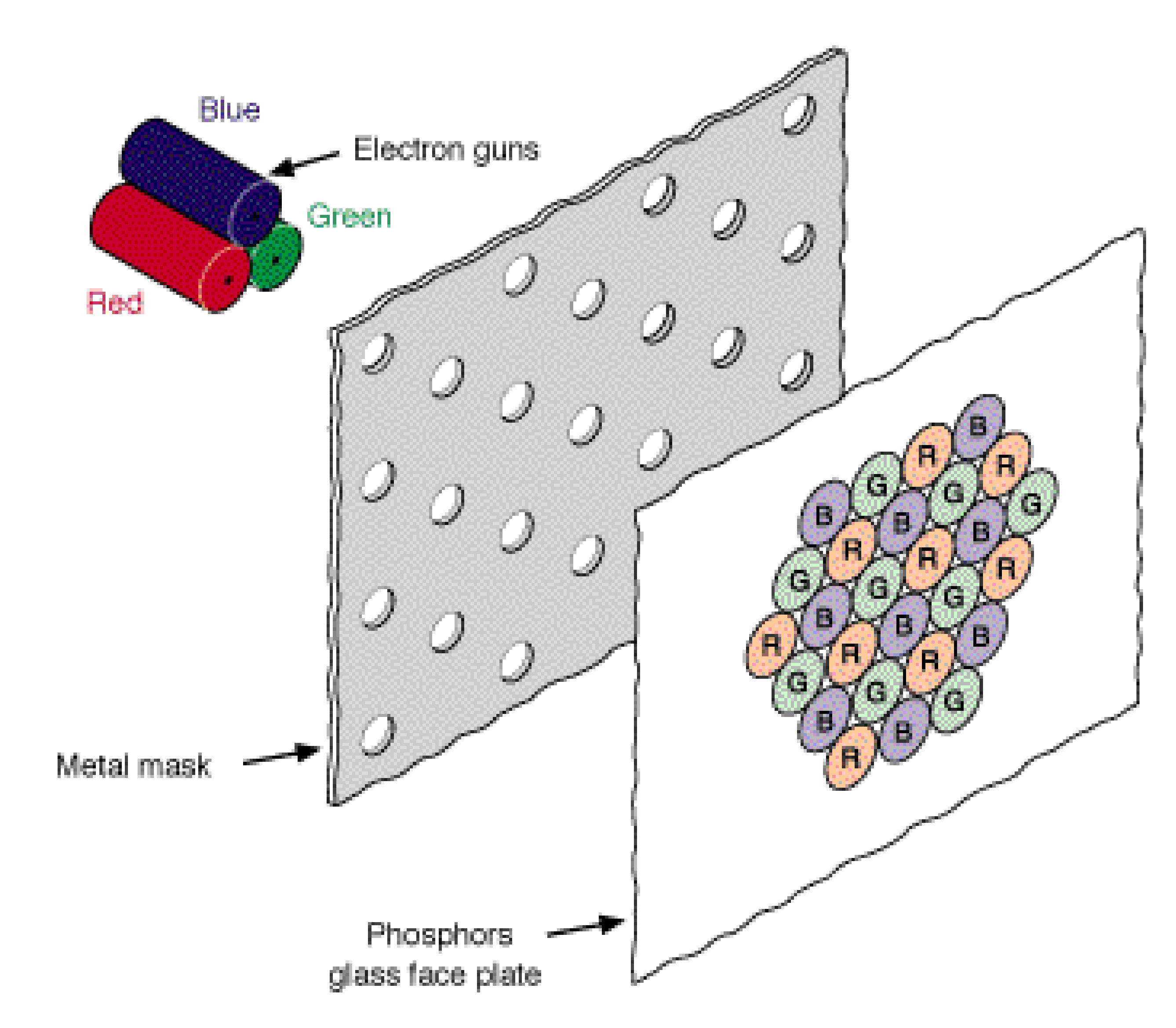


In-line electron gun arrangement

  - why red, green, and blue phosphors?

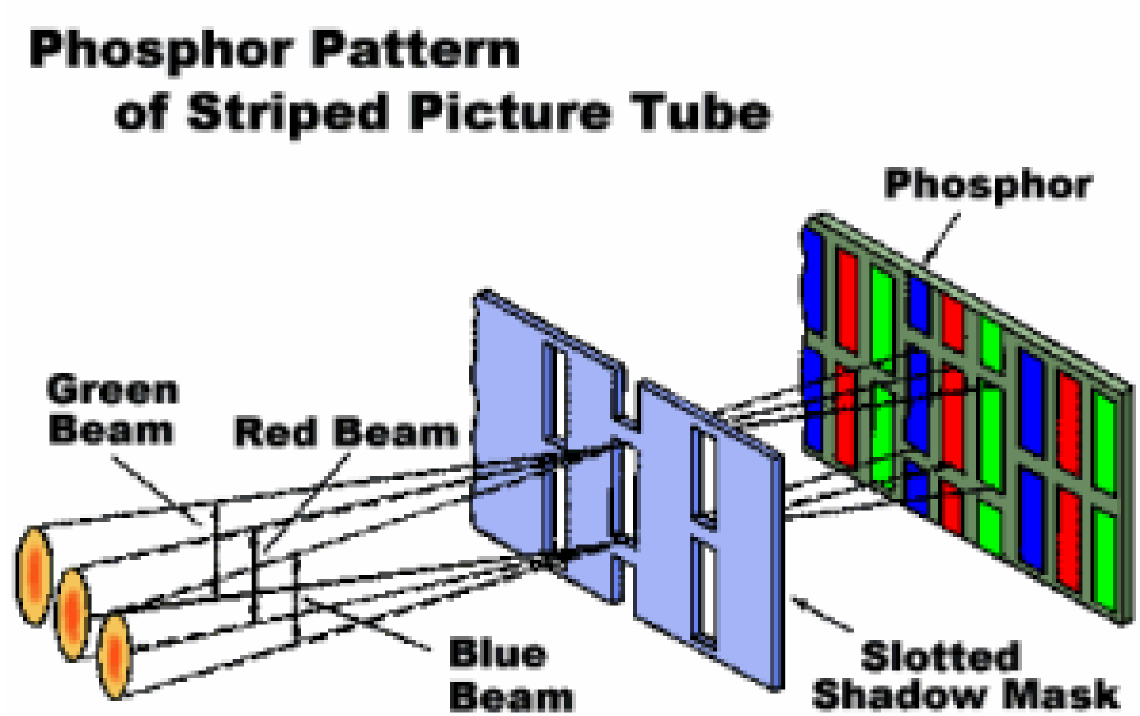
Color CRTs

- three electron guns
- metal *shadow mask* to differentiate beams



Color CRTs

- three electron guns
- metal *shadow mask* to differentiate beams



Raster Discussion

- raster CRT pros
  - allows solids, not just wireframes
  - leverages low-cost CRT technology (i.e., TVs)
  - bright! display *emits* light
- cons
  - requires screen-size memory array
  - discrete sampling (pixels)
  - practical limit on size (call it 40 inches)
  - bulky
  - finicky (convergence, warp, etc)

CRTs – Summary

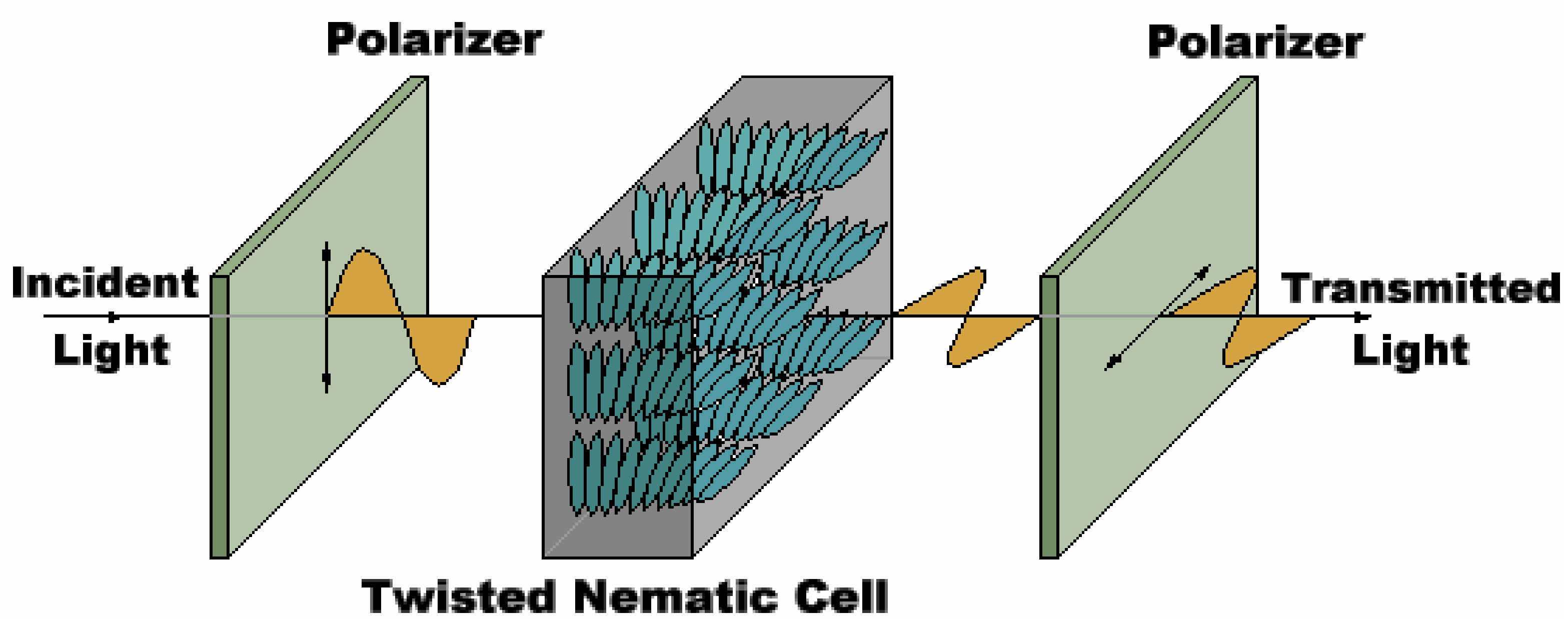
- CRT technology hasn't changed much in 50 years
- early television technology
  - high resolution
  - requires synchronization between video signal and electron beam vertical sync pulse
- early computer displays
  - avoided synchronization using 'vector' algorithm
  - flicker and refresh were problematic

CRTs – Summary

- raster displays (early 70s)
  - like television, scan all pixels in regular pattern
  - use frame buffer (video RAM) to eliminate sync problems
  - RAM
    - ¼ MB (256 KB) cost $2 million in 1971
    - do some math…
      - 1280 x 1024 screen resolution = 1,310,720 pixels
      - monochrome color (binary) requires 160 KB
      - high resolution color requires 5.2 MB

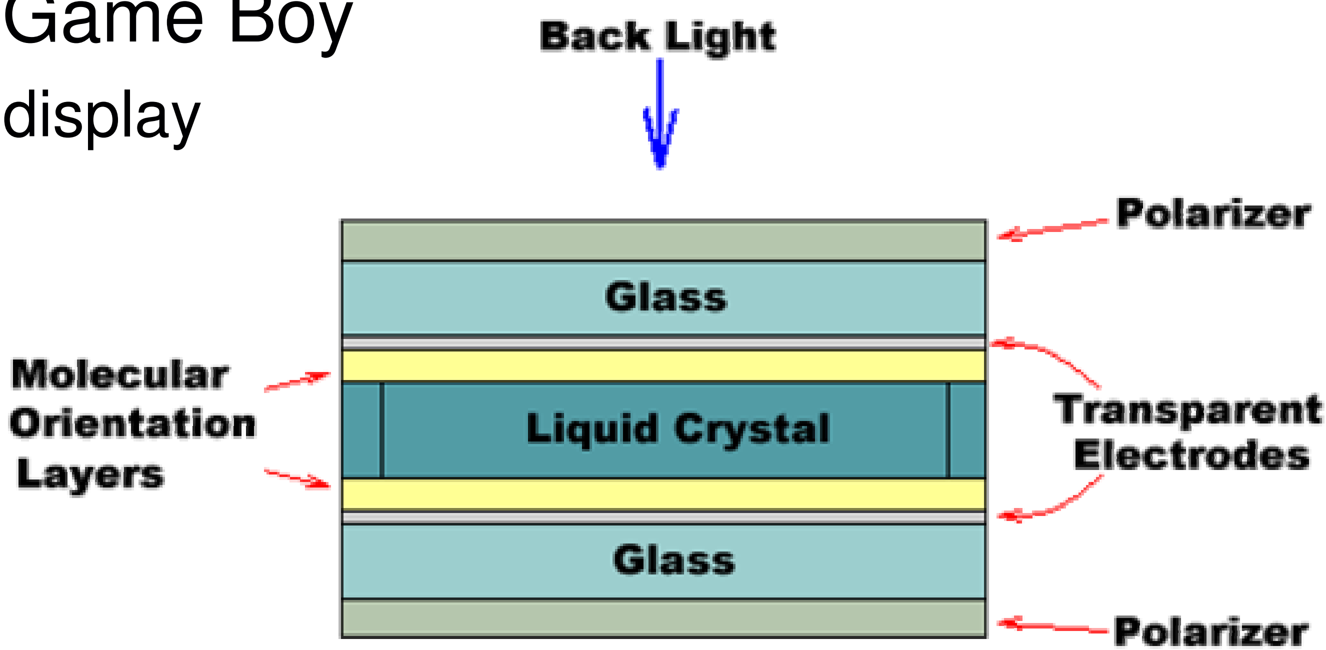
LCDs

- Liquid Crystal Displays (LCDs)
  – organic molecules, naturally in crystalline state, that liquefy when excited by heat or E field
  – crystalline state twists polarized light 90º.



LCDs

- transmissive & reflective LCDs:
  - LCDs act as light valves, not light emitters, and thus rely on an external light source.
  - laptop screen: backlit, transmissive display
  - Palm Pilot/Game Boy
    - reflective display

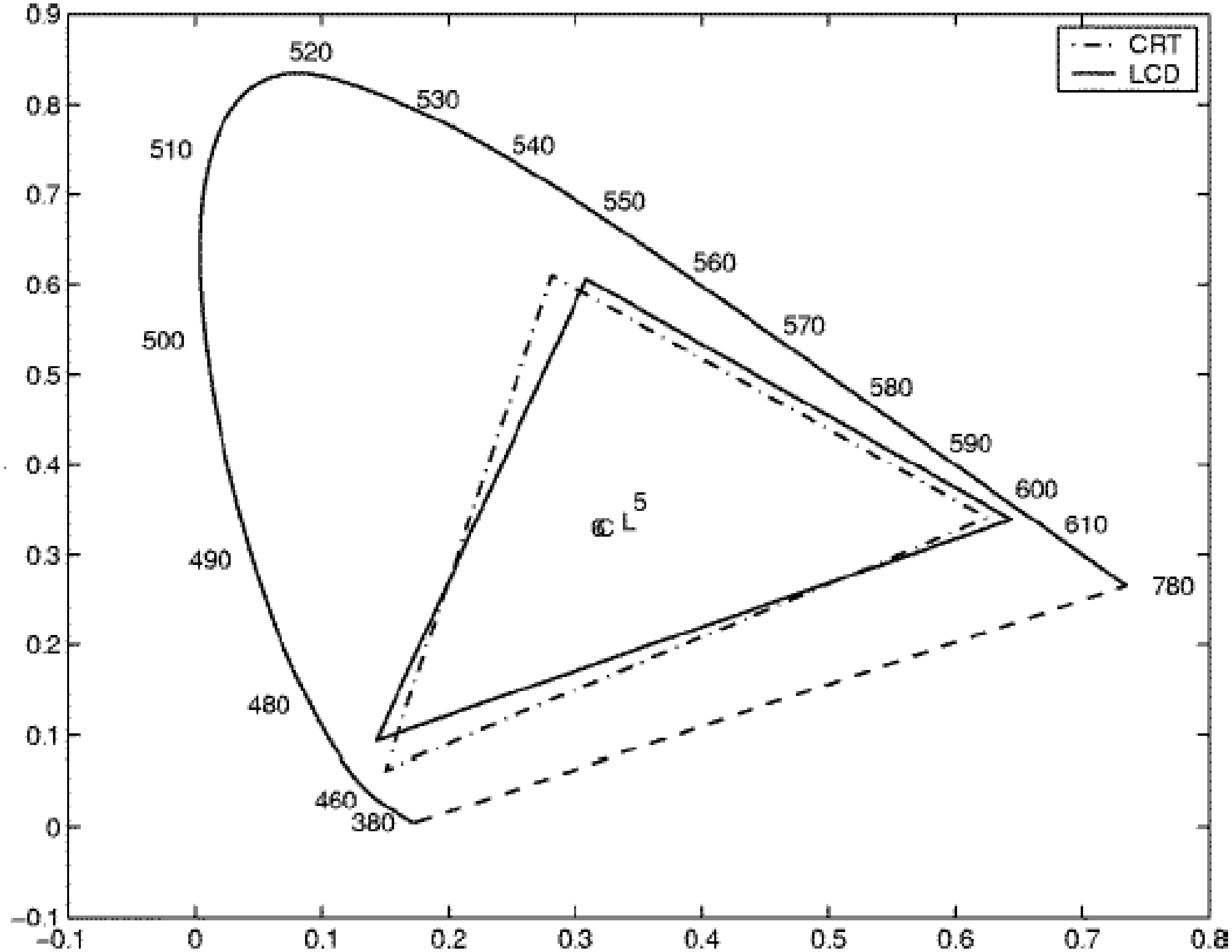


High-Resolution LCDs

- IBM T221 Flat Panel, US $8K
  - ASCI brought technology to market early
  - 3800x2400, 9 Mpixels, 22", 200dpi
  - 179 degree field of view
  - bright, high constrast (400:1)

- LCD pros
  - much lighter, thinner than CRTs
  - price nearly competitive with CRTs

CRT vs LCD Color Gamuts

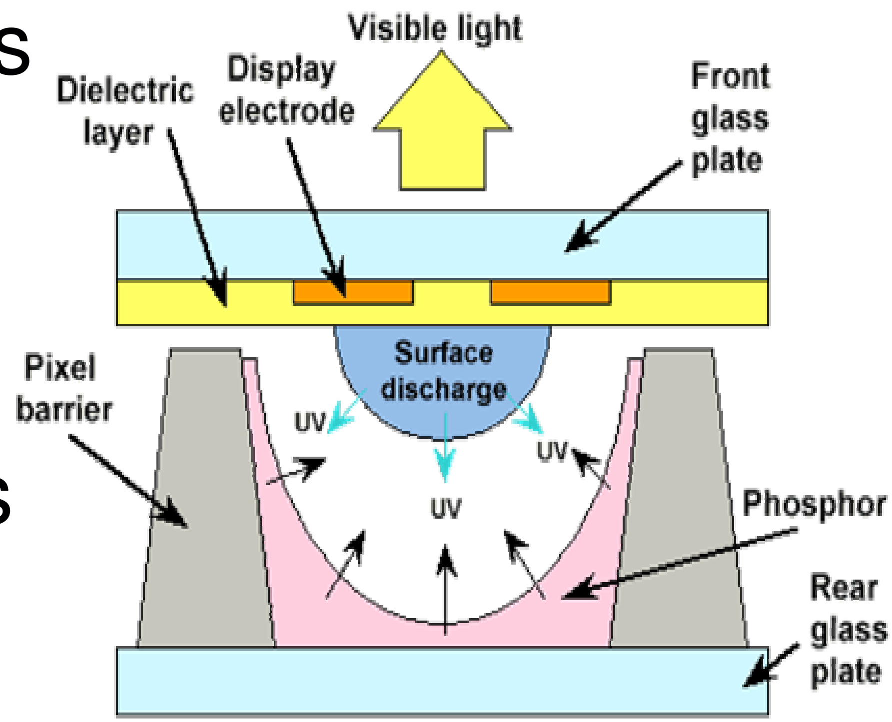


http://www.student.cs.uwaterloo.ca/~cs781/Sharma02LCDs.pdf

LCDs Versus CRTs: Color Calibration and Gamut Considerations, by Gaurav Sharma

Plasma Display Panels

- similar in principle to fluorescent light tubes
- small gas-filled capsules excited by electric field, emit UV light
- UV excites phosphor
- phosphor relaxes, emits some other color

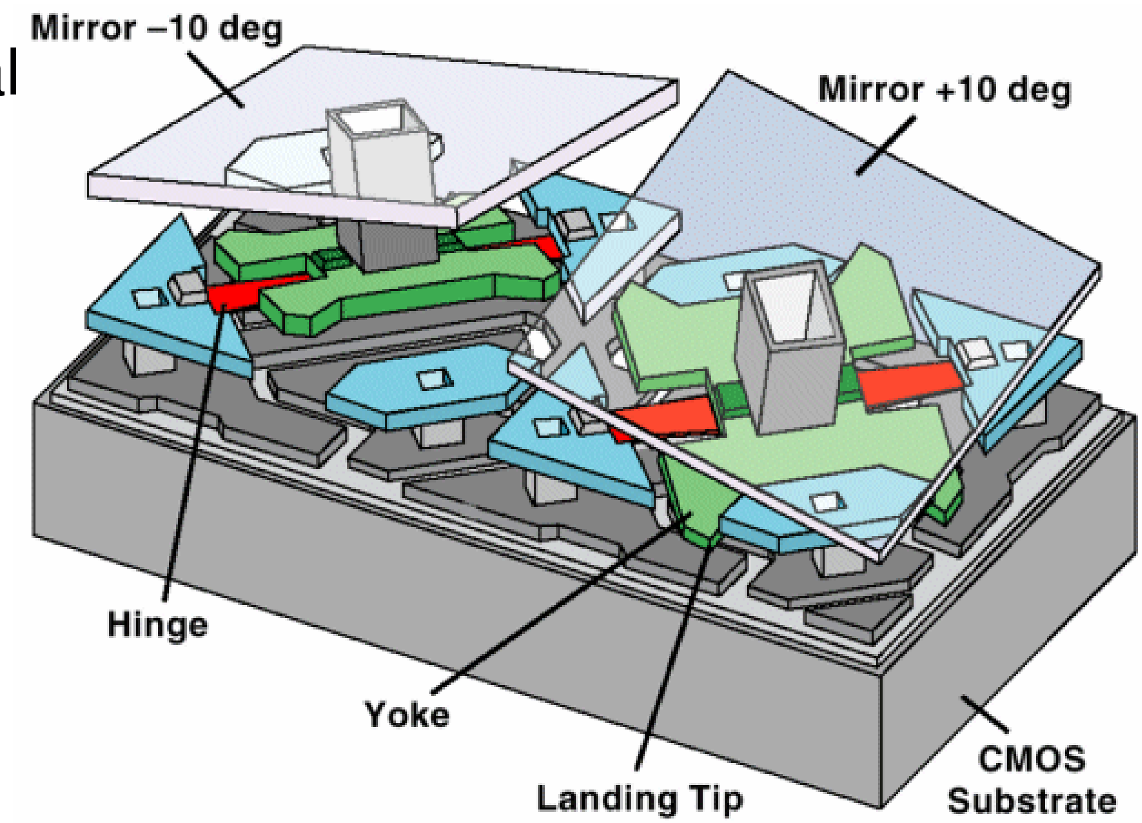


Plasma Display Discussion

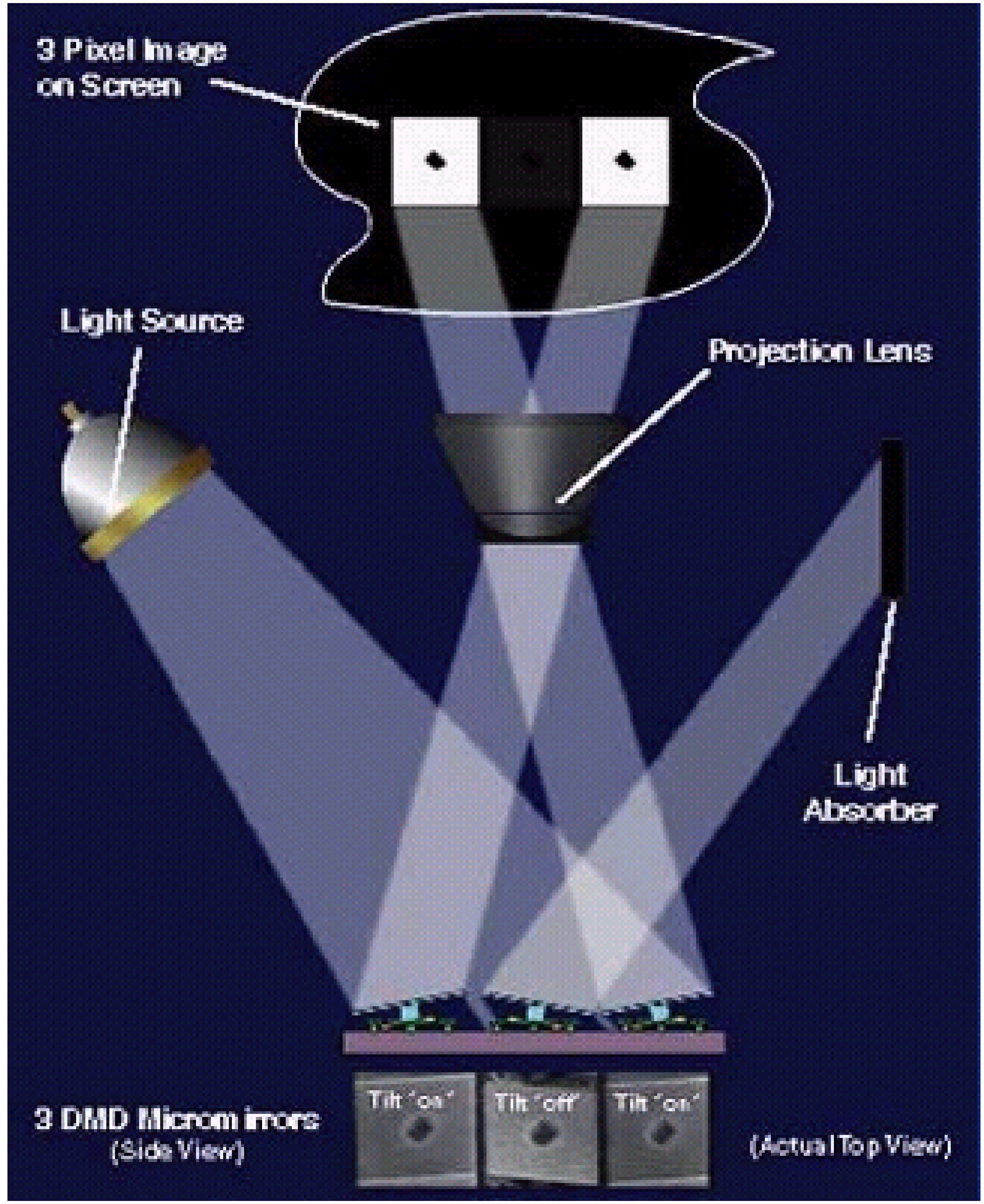
- pros
  - large viewing angle
  - good for large-format displays
  - fairly bright
- cons
  - expensive
  - large pixels (~1 mm versus ~0.2 mm)
  - phosphors gradually deplete
  - less bright than CRTs, using more power

DMD / DLP Projectors

- Digital Micromirror Devices
- Digital Light Processing
  - Microelectromechanical (MEM) devices, fabricated with VLSI techniques



DMD / DLP


3 Pixel Image
on Screen
Light Source
Projection Lens
Light
Absorber
3 DMD Micromirrors
(Side View)
Tilt 'on'
Tilt 'off'
Tilt 'on'
(Actual Top View)

DMD / DLP Discussion

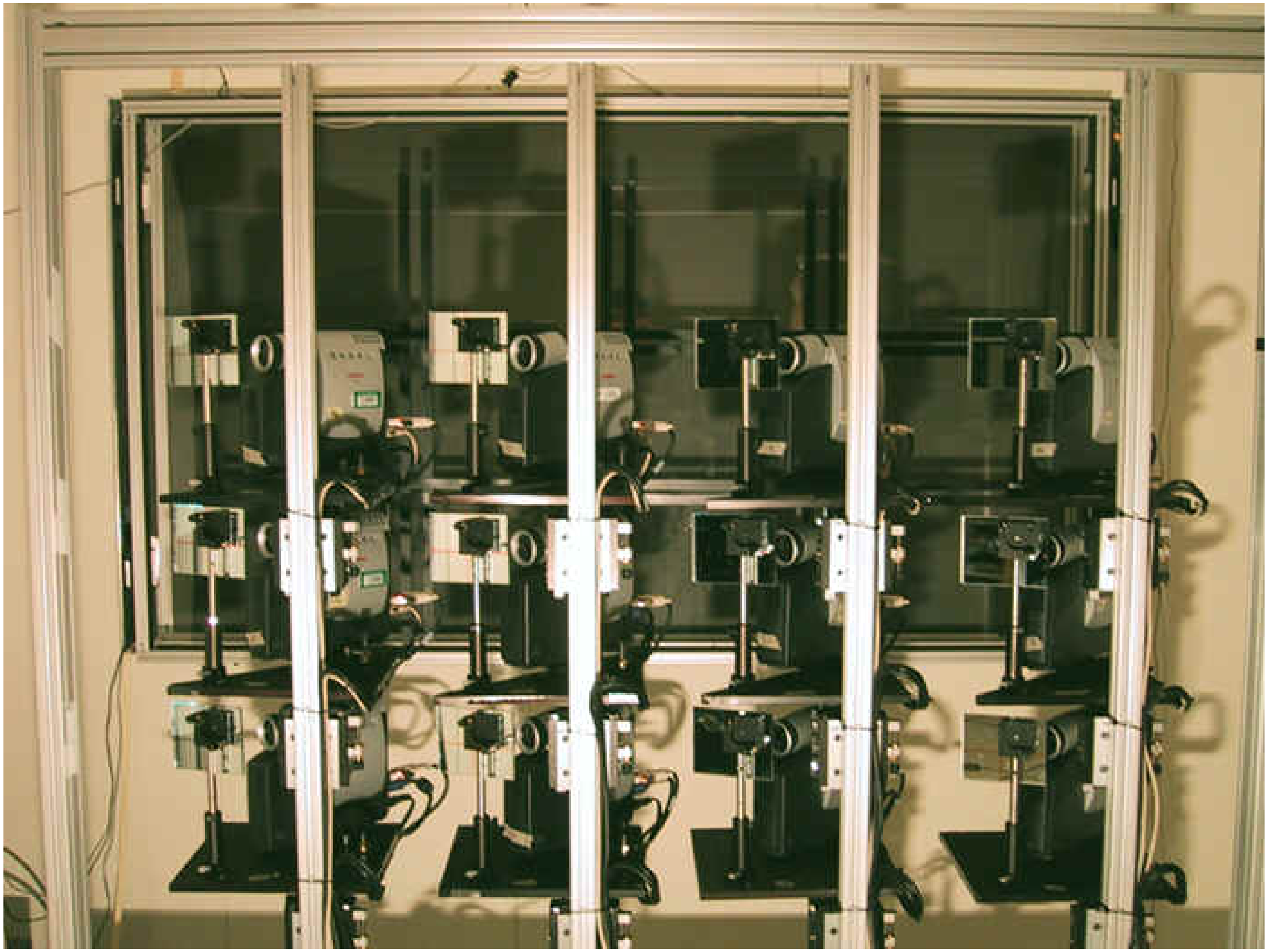
- DMDs are truly digital pixels
- vary grey levels by modulating pulse length
- color: multiple chips, or color-wheel
- pros
  - great resolution
  - very bright
- cons
  - flicker problems

Display Walls

- tiled from multiple projectors: high-resolution

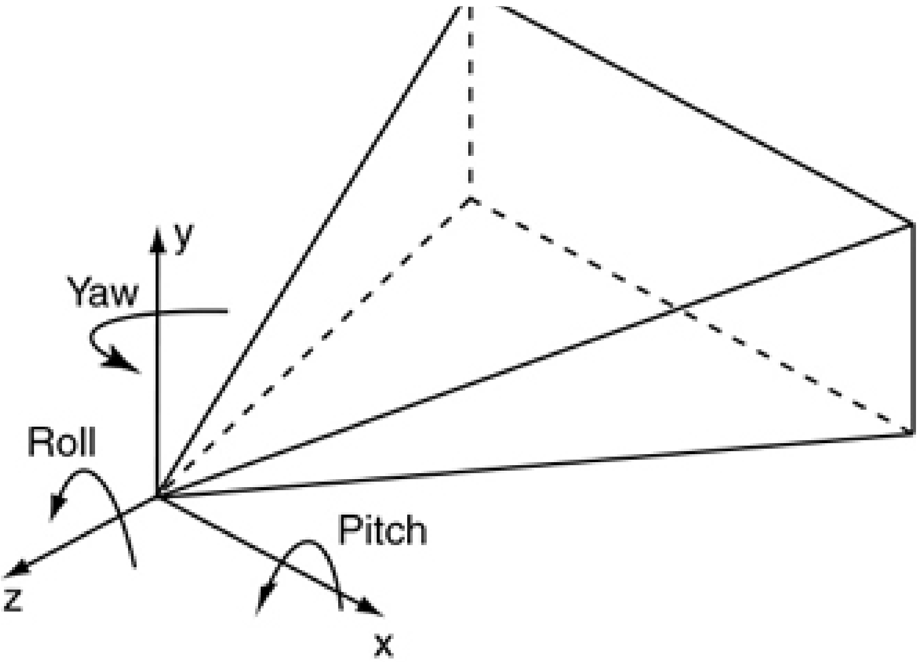
Stanford: [www.cs.umd.edu/~francois/Papers/UIST2001/PostBrainstorm.pdf]

Rear-Projected Array

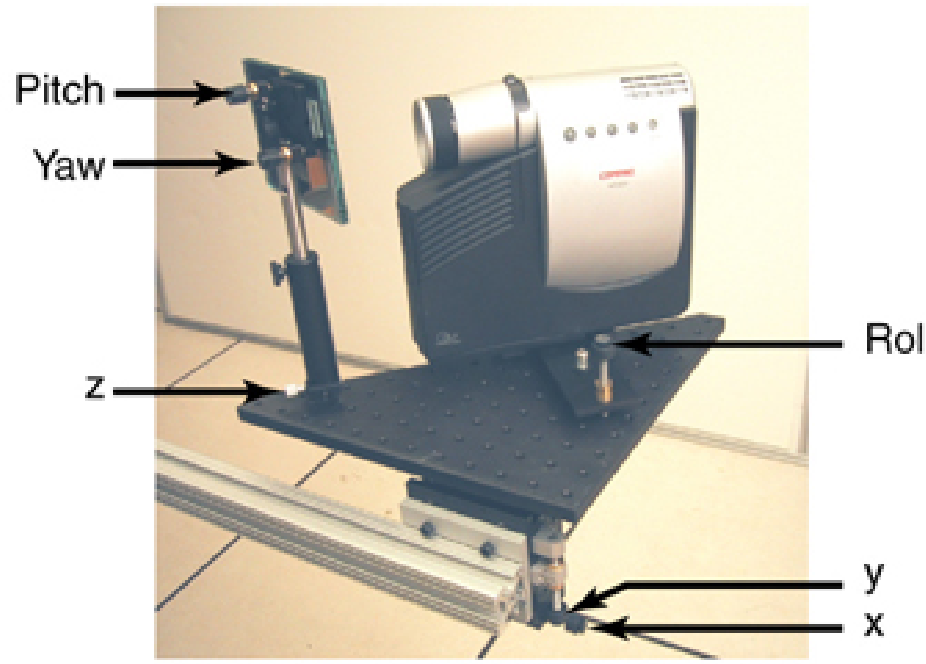


[www.cs.umd.edu/~francois/Mural]

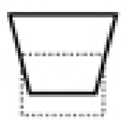
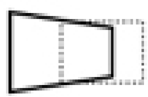
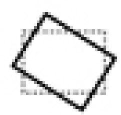
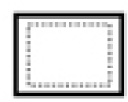
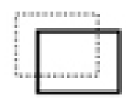
Projector Alignment: Geometric



a)



(b)

Parameter	Pitch (keystone)	Yaw (keystone)	Roll	z	x, y
Effect					
Cross-talks	Yaw, Roll, x, y, z	Ptich, Roll, x, y, z	x, y	x	

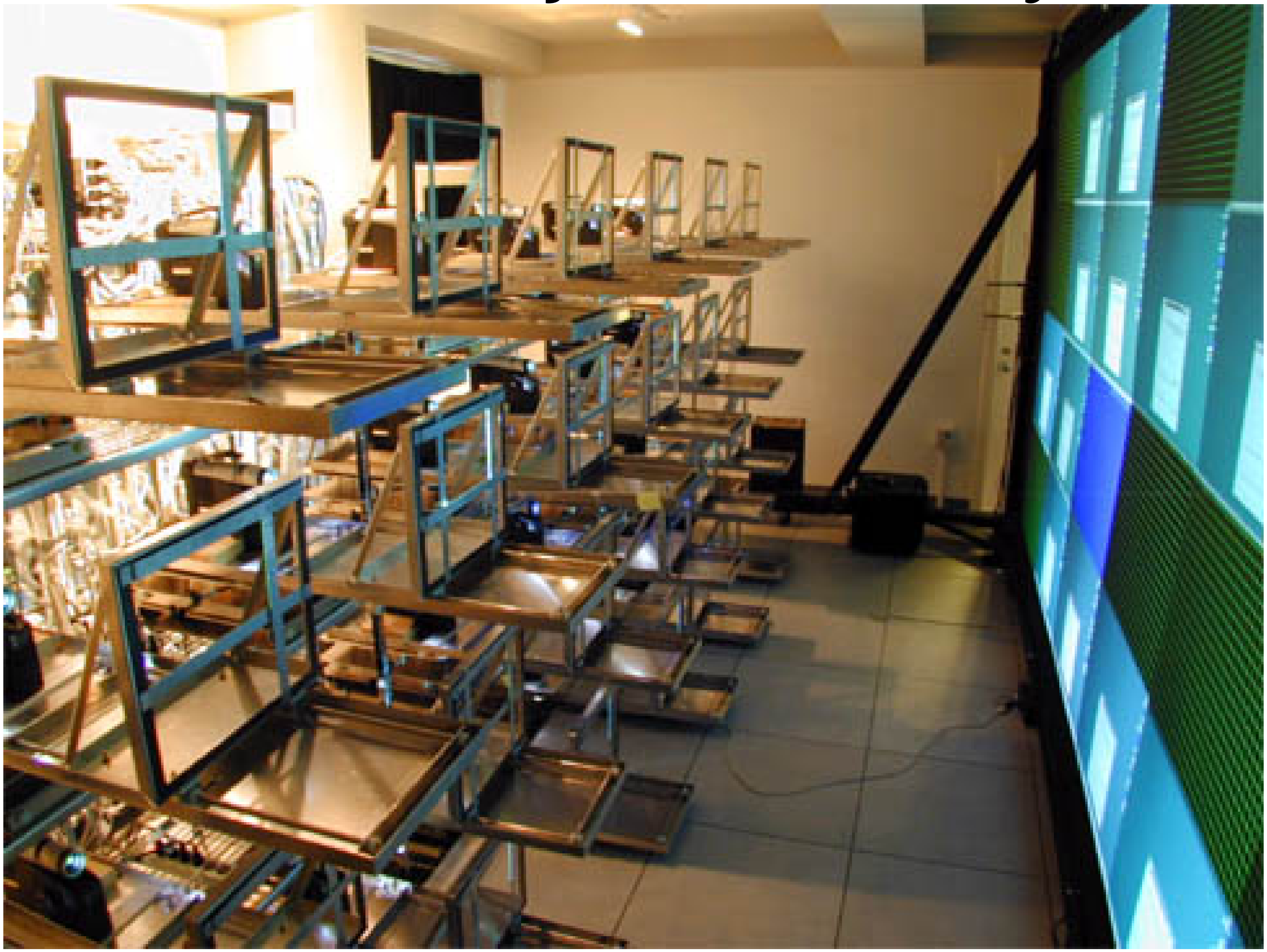
(c)

Tiled Display Walls

- tiled from multiple projectors

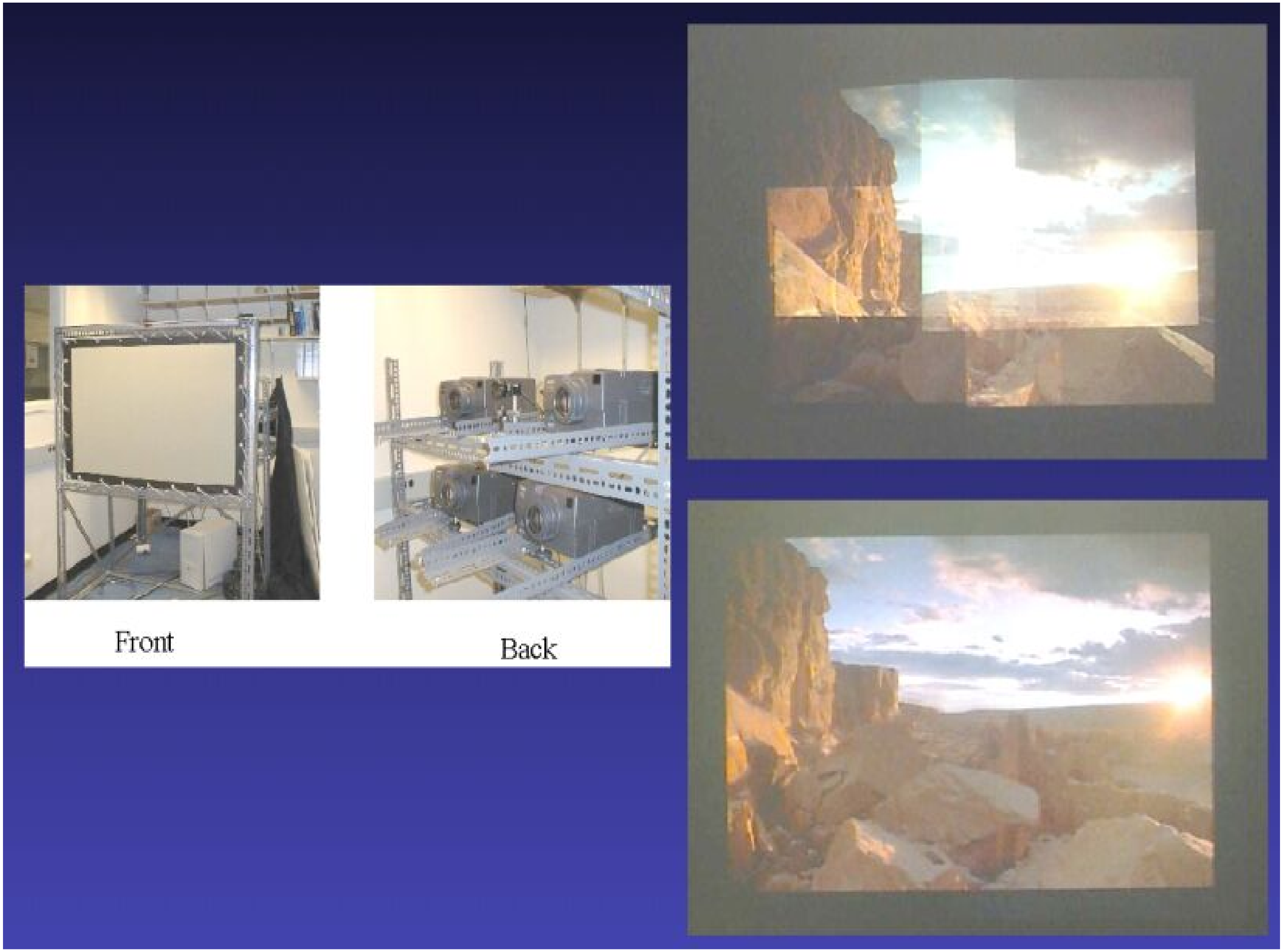
Princeton Wall

Rear-Projected Array



http://www.cs.princeton.edu/omnimedia/papers/ipt2003.pdf

Projector Alignment: Colorimetric



Display Wall Discussion

- pros
  - commodity technology
  - can be seamless (theoretically)
- cons
  - geometric alignment solvable
  - colorimetric alignment difficult
  - large space footprint

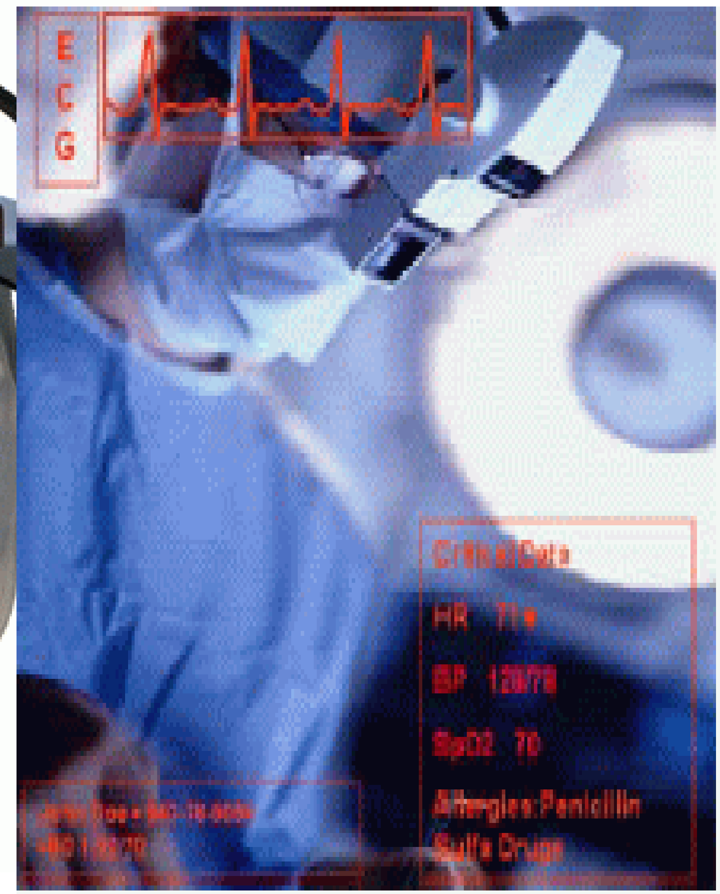
Future: Plentiful Pixels?

- digital wallpaper
  - 300dpi, ubiquitous
  - cheap as paint/wallpaper
- projectors as lightbulbs, flashlights

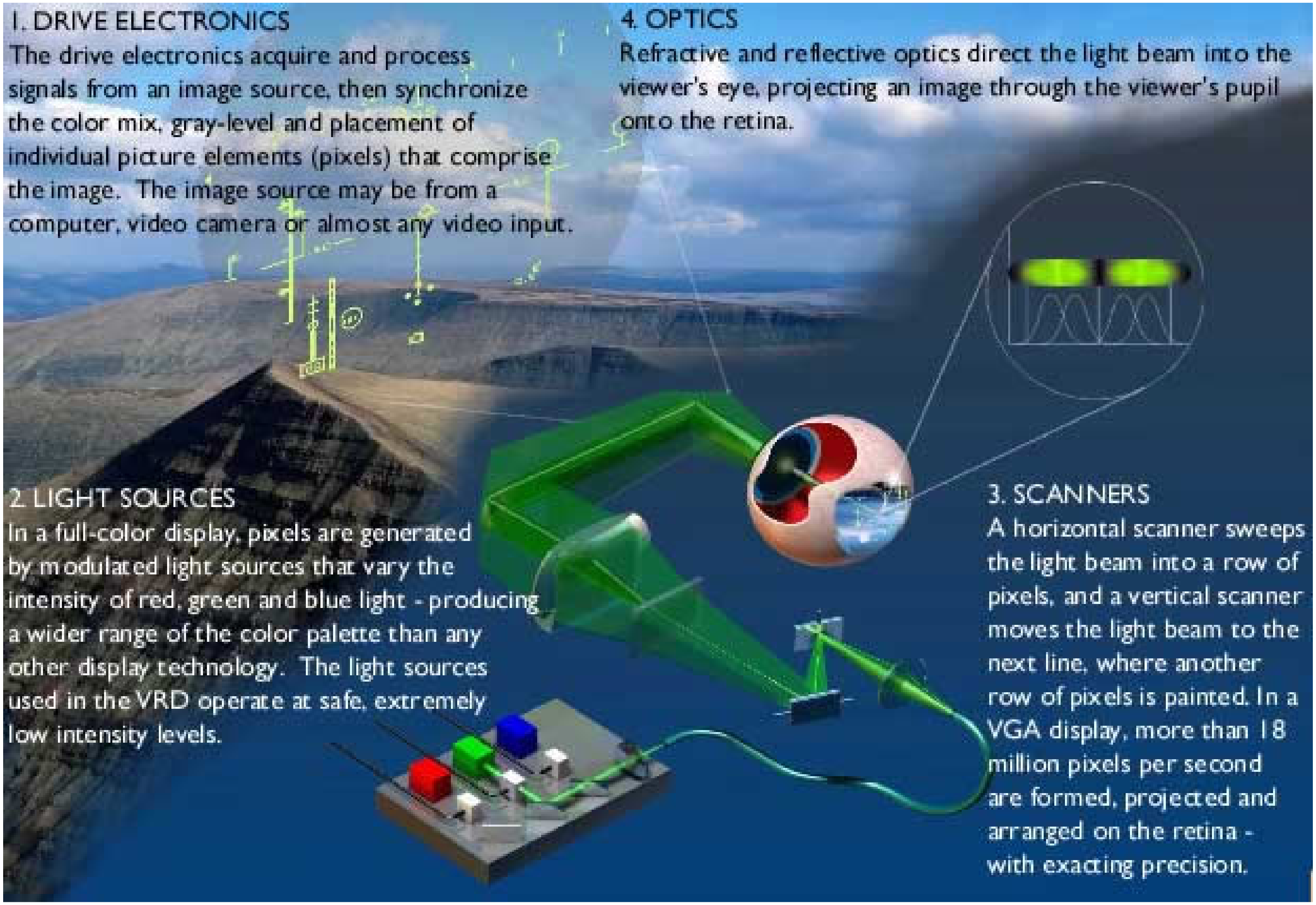
- challenges
  - rendering
  - physical delivery of pixels to displays
    - would need lots of wires

Mobile Displays

640x480 1” colour
virtual image 2 ft away
3 oz



Mobile Displays

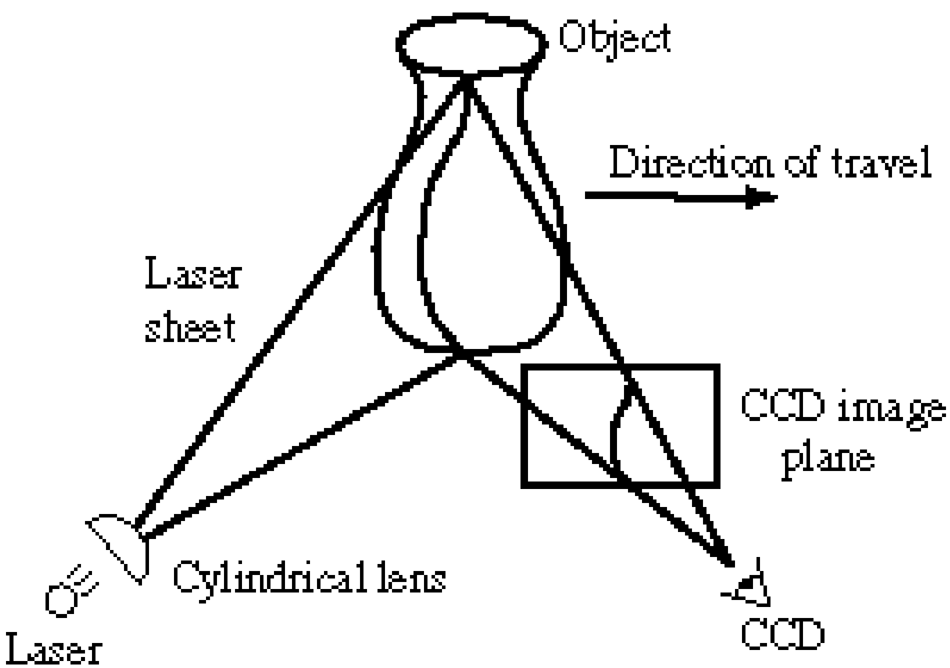


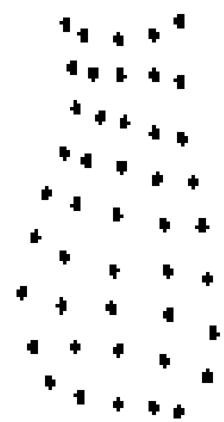
Stereo Displays

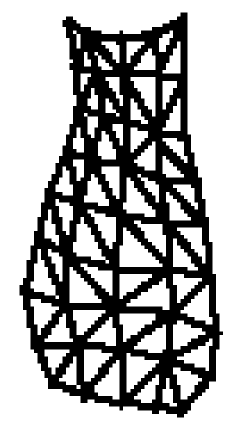
- active glasses or active screen
  - autostereoscopic also possible

Laser Stripe Range Scanners

- camera records laser stripe
  - second camera records texture image







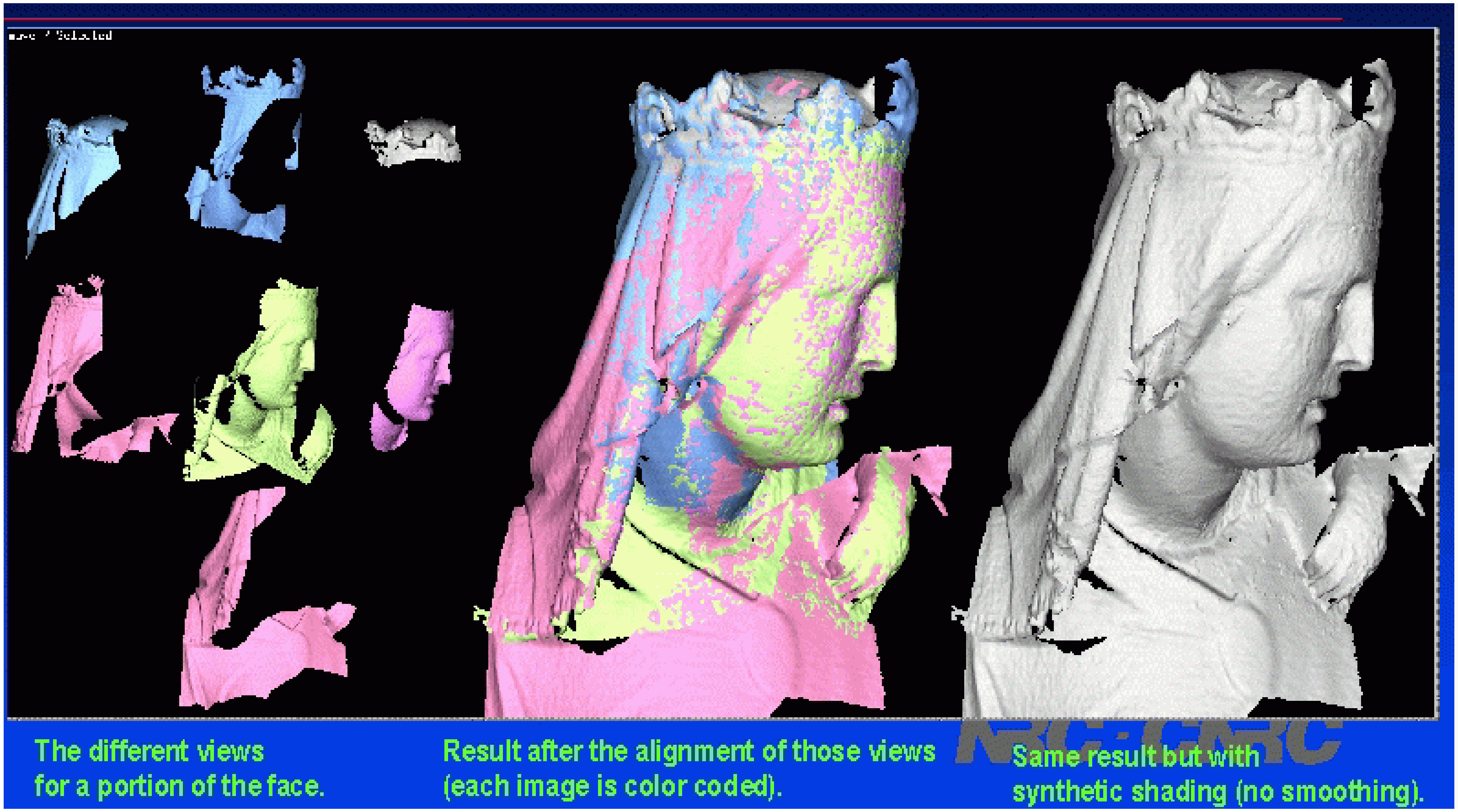
[graphics.stanford.edu/papers/volrange]

Laser Stripe Range Scanners

Cyberware

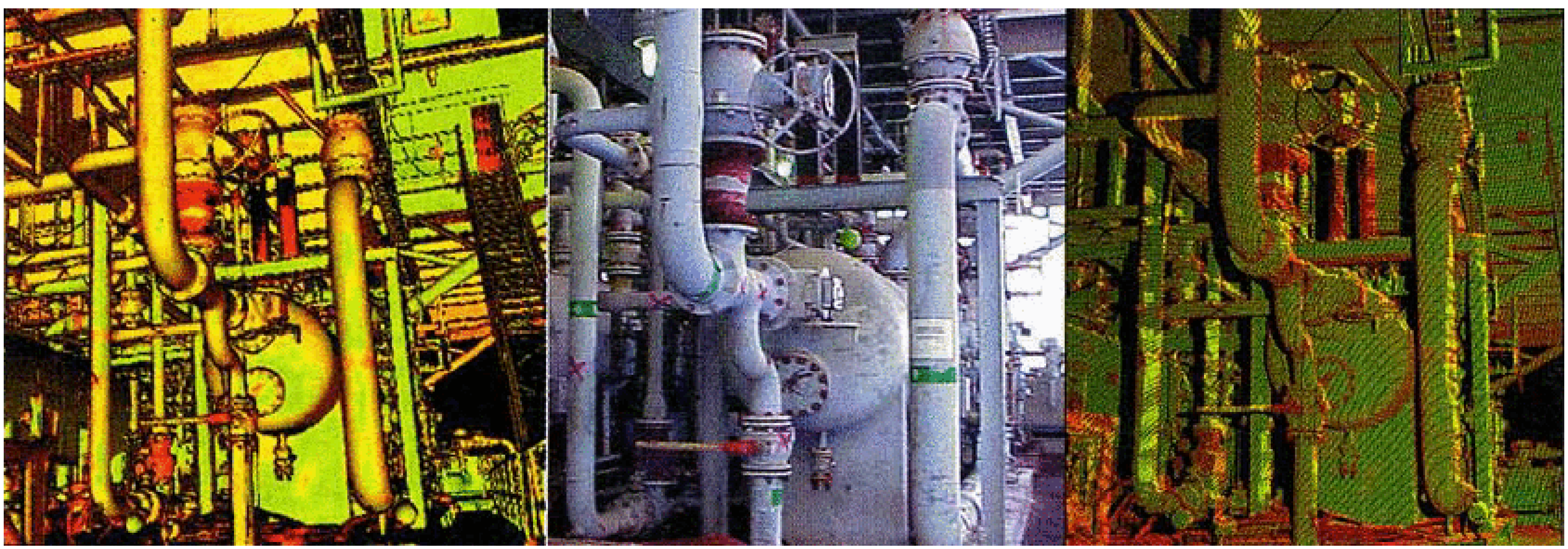
BIRIS

Laser Stripe Range Scanners

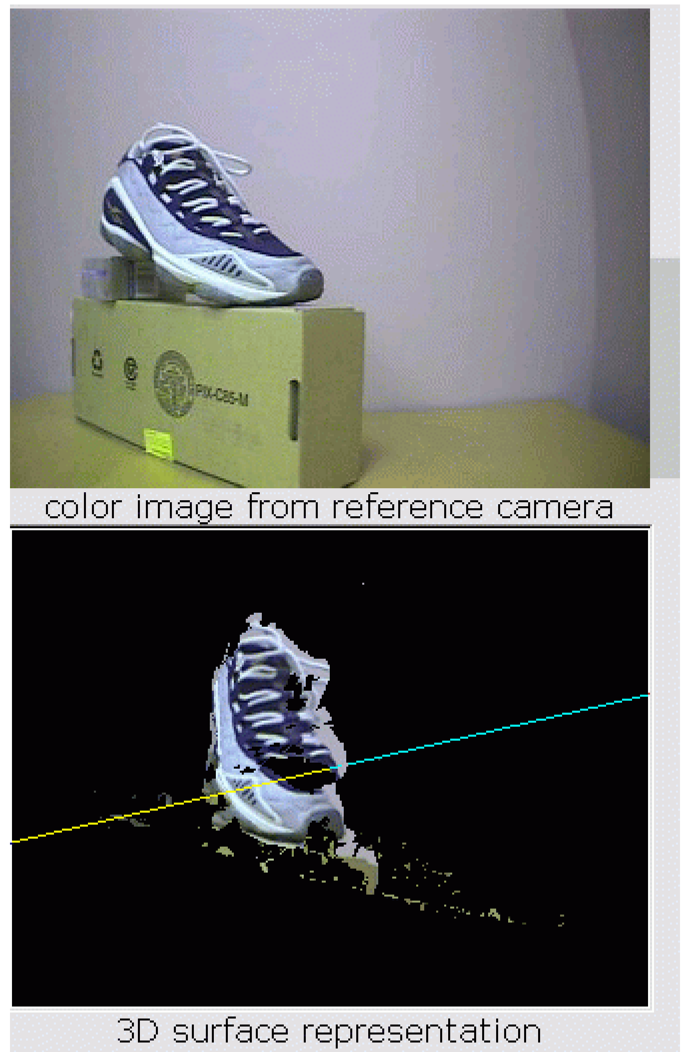


Laser Time-of-Flight Scanners

- Cyra
  - picosecond clock rates

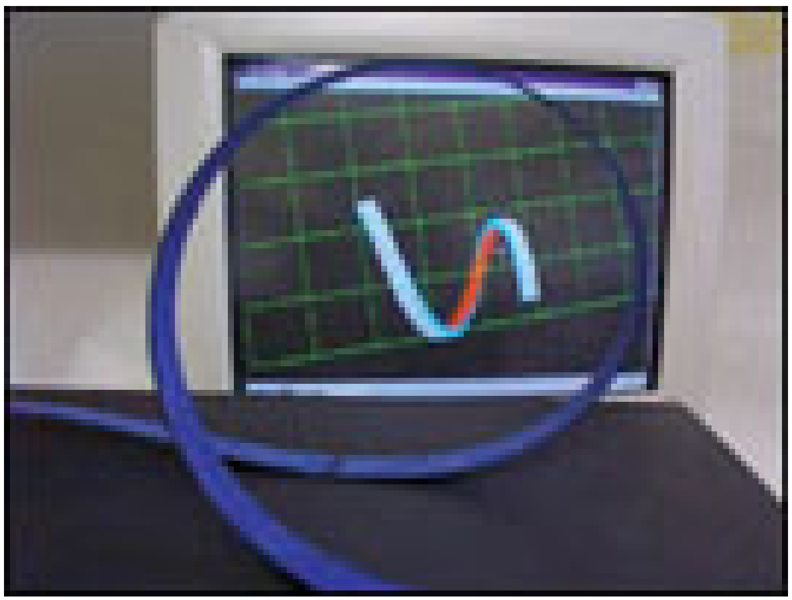


Depth from Stereo



Shape Tape

– fiber-optic based bend-and-twist sensor



Haptics

3D Printers

- spread layer of powder
- print binder solution
- vacuum away loose powder

4.5 hrs printing,
$100 printing cost
electroplated

[Z Corp]

3D Printers

printing telephones?
etc.