



**University of British Columbia**  
**CPSC 414 Computer Graphics**

**Displays, Devices II**

**Week 12, Wed 19 Nov 2003**

# News

- extra office hours in lab
  - 5:15-6:15 today
- project 3 **draft** out

# Display Technologies recap

- CRT: Cathode Ray Tubes
- LCD: Liquid Crystal Displays
- plasma display panels
- DMD/DLP: micromirror array projectors
- display walls: tiled projector array

# Display Wall Discussion

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

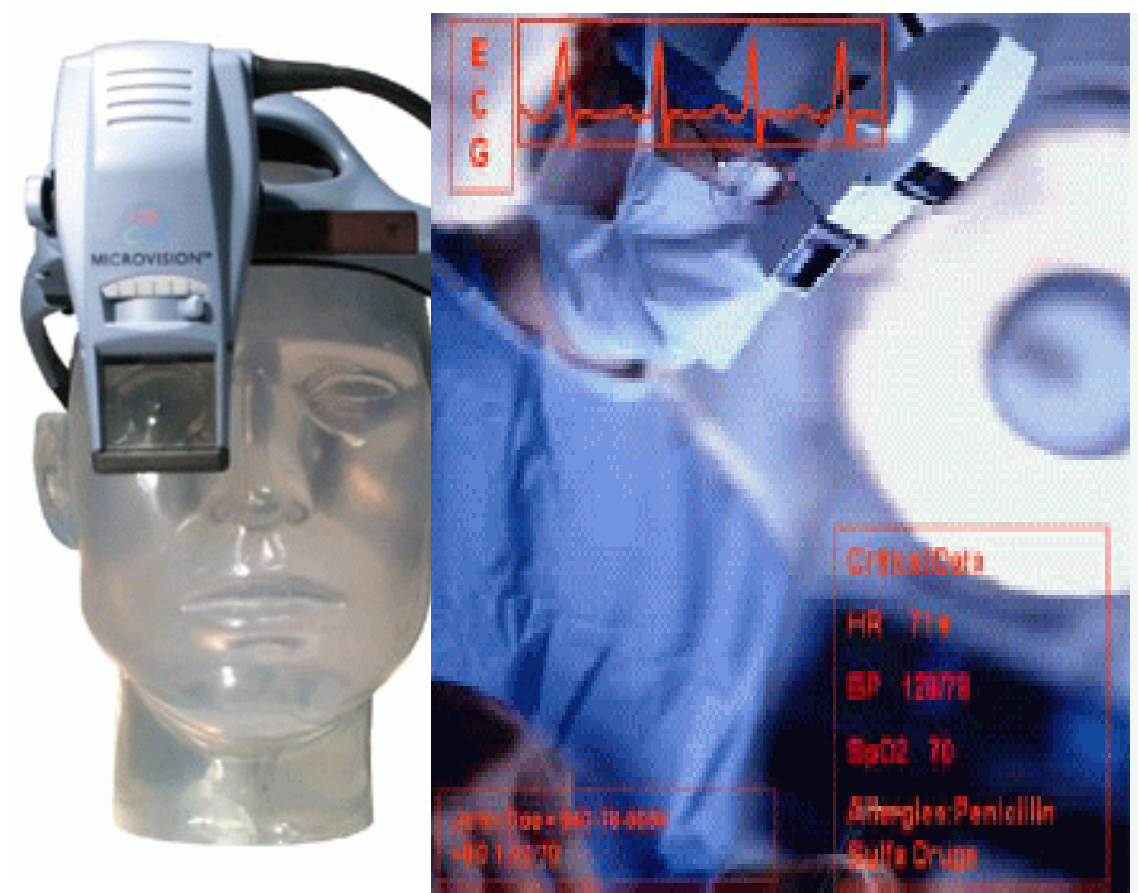
# Future: Plentiful Pixels?

- 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

## 1. DRIVE ELECTRONICS

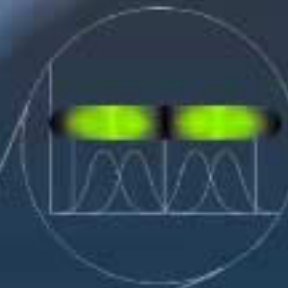
The drive electronics acquire and process signals from an image source, then synchronize the color mix, gray-level and placement of individual picture elements (pixels) that comprise the image. The image source may be from a computer, video camera or almost any video input.

## 2. LIGHT SOURCES

In a full-color display, pixels are generated by modulated light sources that vary the intensity of red, green and blue light - producing a wider range of the color palette than any other display technology. The light sources used in the VRD operate at safe, extremely low intensity levels.

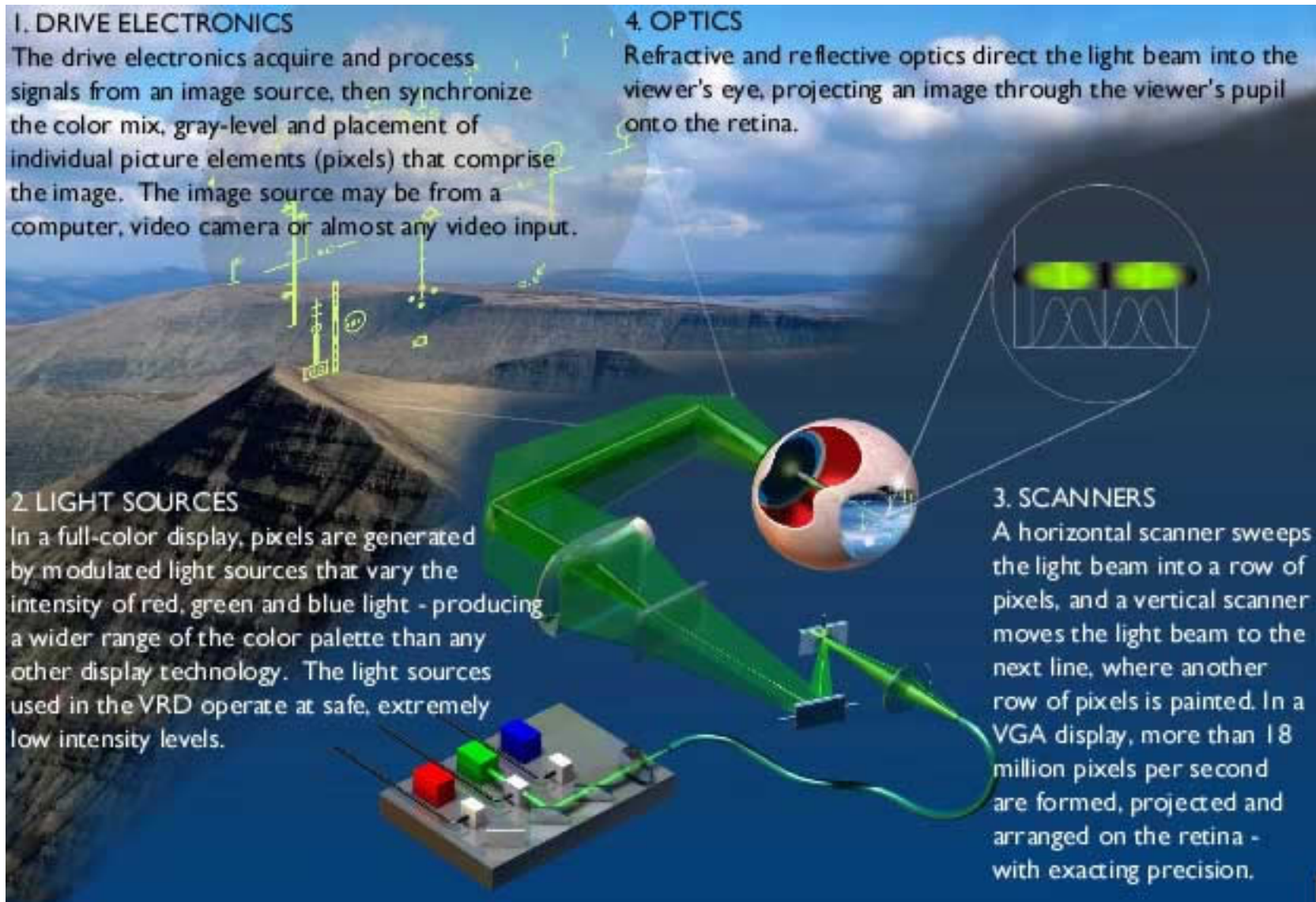
## 4. OPTICS

Refractive and reflective optics direct the light beam into the viewer's eye, projecting an image through the viewer's pupil onto the retina.



## 3. SCANNERS

A horizontal scanner sweeps the light beam into a row of pixels, and a vertical scanner moves the light beam to the next line, where another row of pixels is painted. In a VGA display, more than 18 million pixels per second are formed, projected and arranged on the retina - with exacting precision.



# Stereo Displays

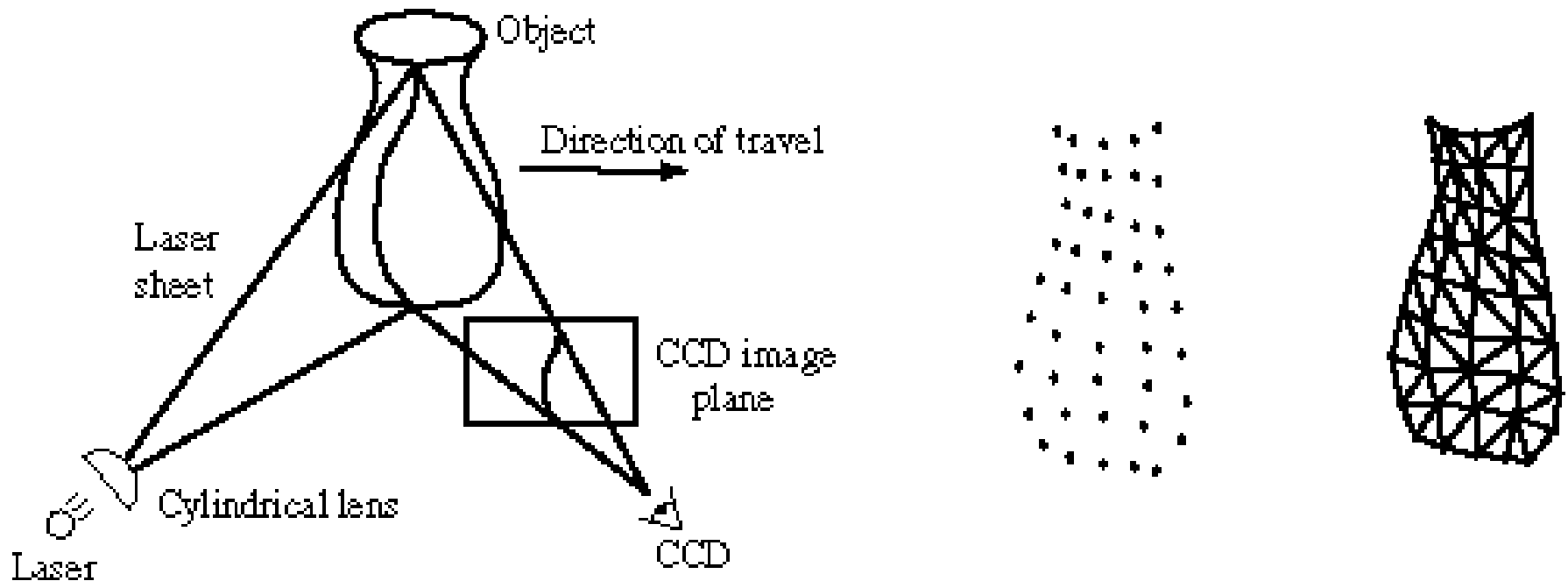
- active glasses or active screen
  - autostereoscopic also possible





# Laser Stripe Range Scanners

- camera records laser stripe
  - second camera records texture image



[[graphics.stanford.edu/papers/volrange](http://graphics.stanford.edu/papers/volrange)]

# Laser Stripe Range Scanners

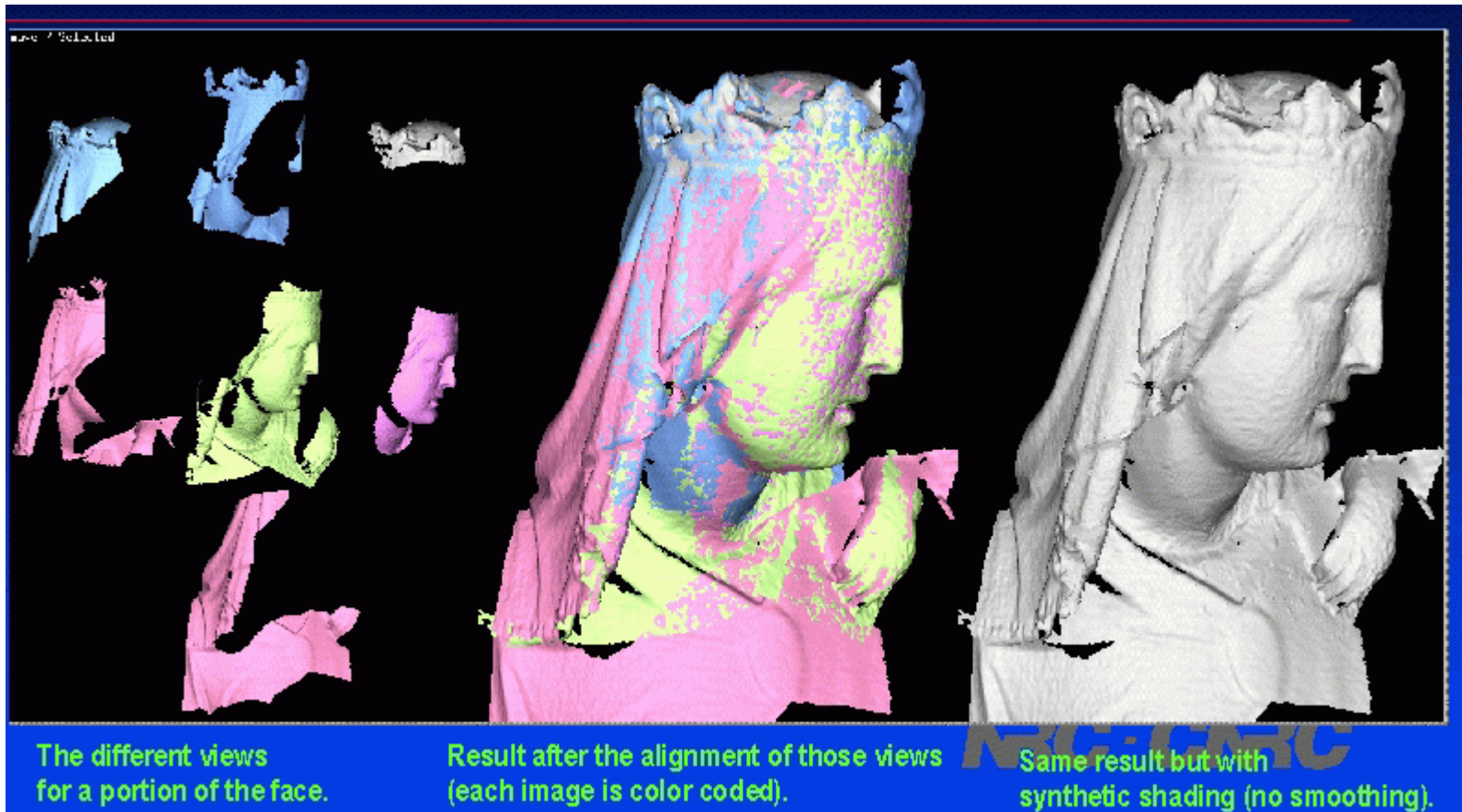
Cyberware



BIRIS

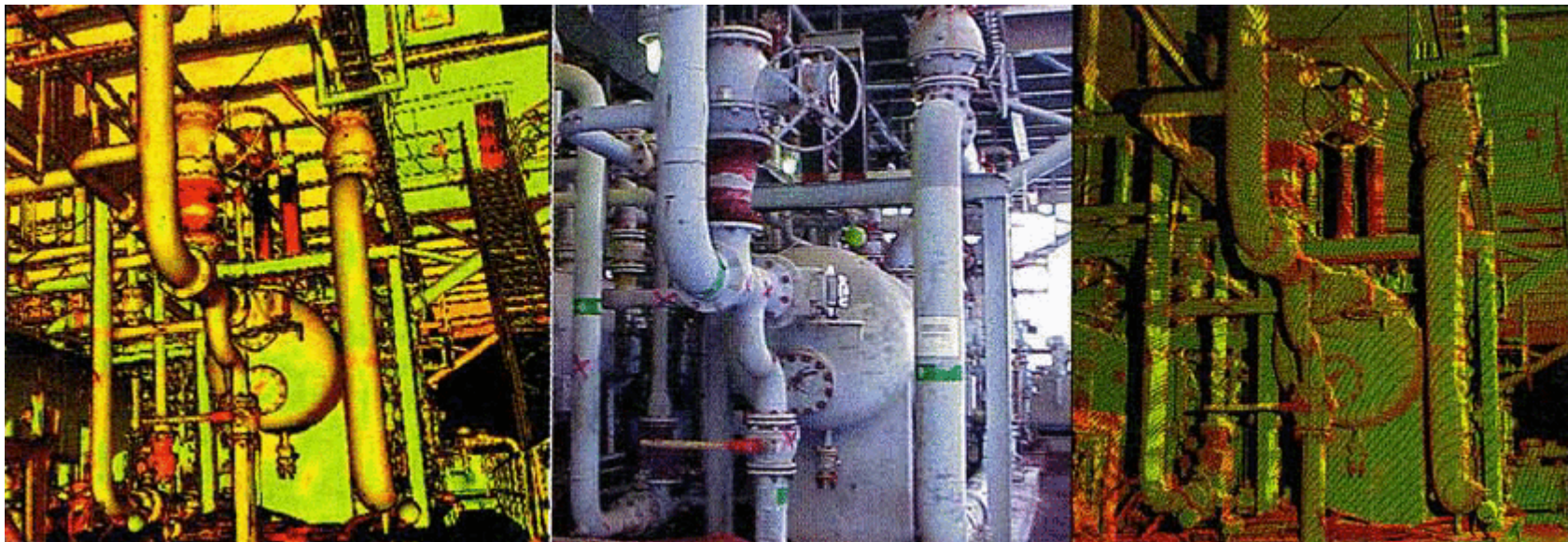


# Laser Stripe Range Scanners

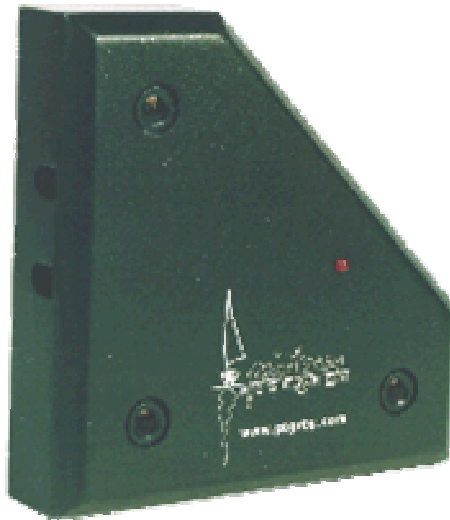


# Laser Time-of-Flight Scanners

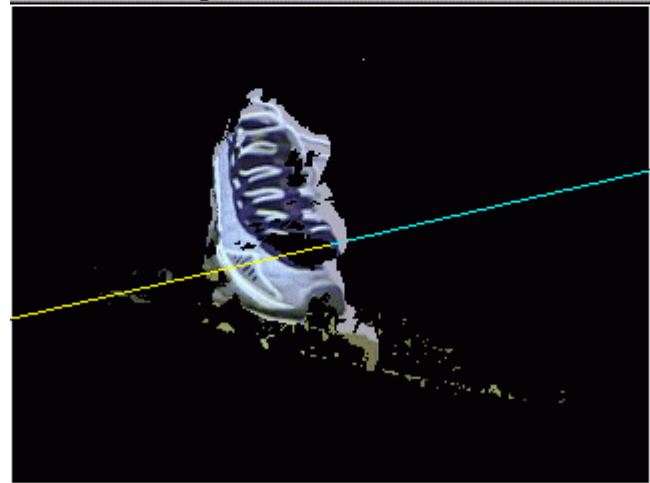
- Cyra
  - picosecond clock rates



# Depth from Stereo



color image from reference camera

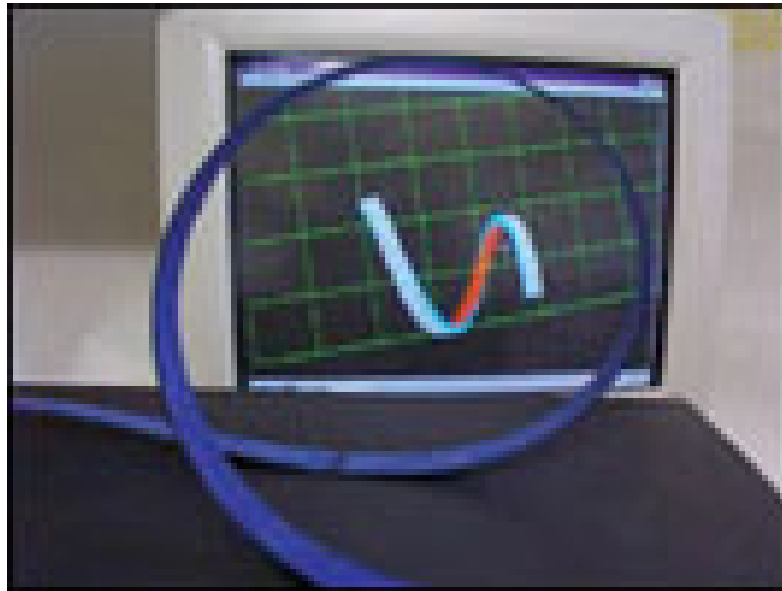


3D surface representation

© Tamara Munzner

# 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**



**Z400**  
3D Printer

The Z400 3D Printer is the entry-level concept modeling solution that delivers great models quickly and inexpensively.  
[Click here for more details](#)

**\$33,500\***

\* Options, shipping, applicable taxes or duties not included.

**[Z Corp]**



# 3D Printers



**printing telephones?  
etc.**

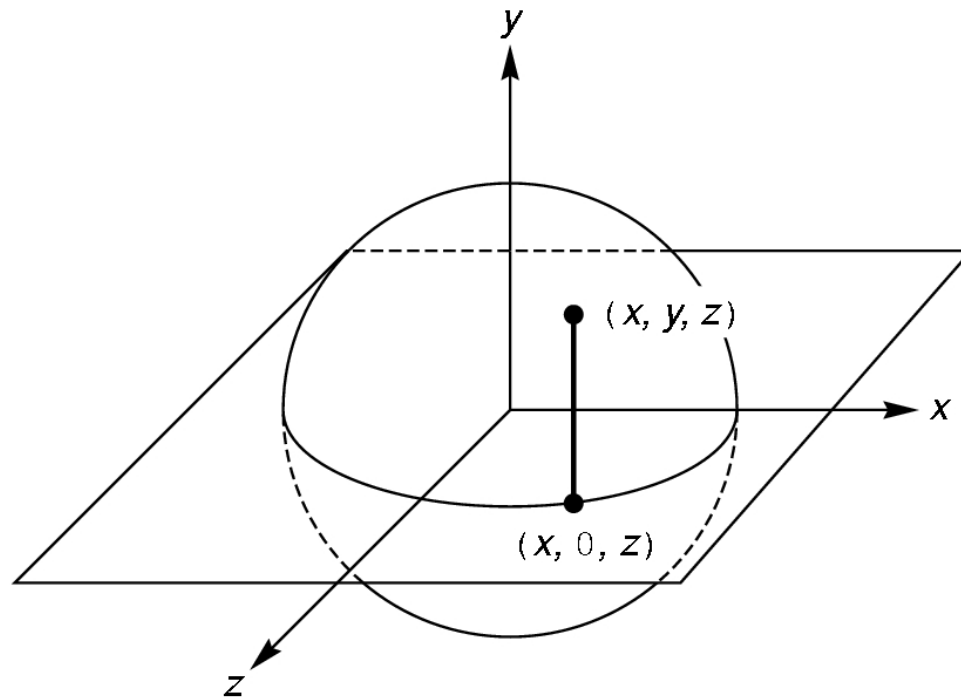


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# Virtual Trackball

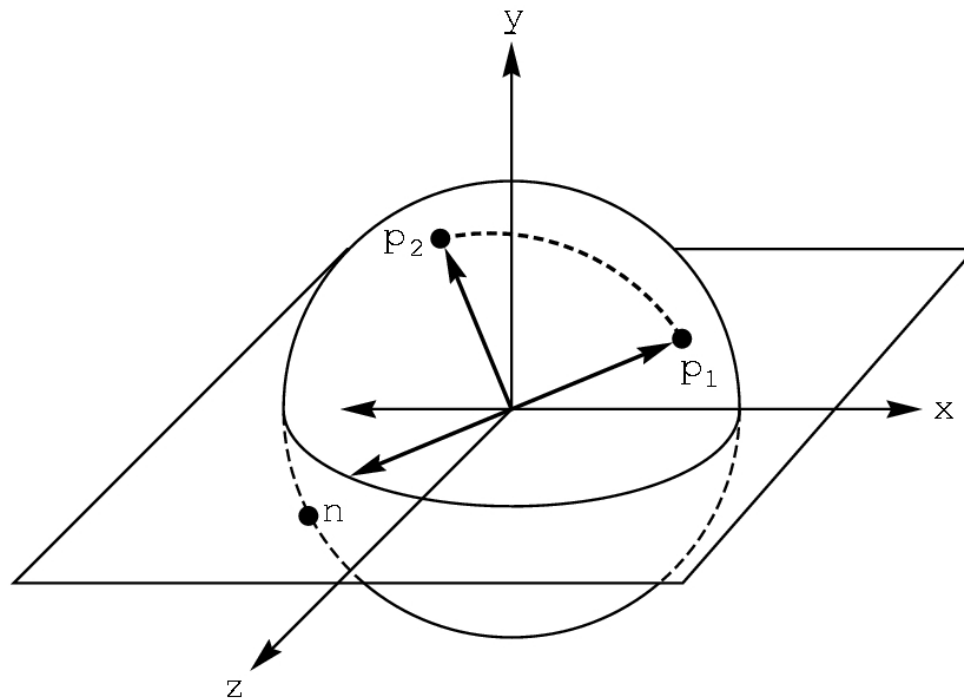
# Virtual Trackball

- imagine a trackball embedded in screen
  - [cs.calvin.edu/CS/352/02Graphics/lectures/primer-demo.exe](http://cs.calvin.edu/CS/352/02Graphics/lectures/primer-demo.exe)
- if I click on screen, what point on trackball am I touching?



# Trackball Rotation Axis

- If I move the mouse from  $\mathbf{p}_1$  to  $\mathbf{p}_2$ , what rotation does that correspond to?



# Virtual Trackball Rotations

- Rotation about the axis  $\mathbf{n} = \mathbf{p}_1 \times \mathbf{p}_2$
- Angle of rotation: use
$$\mathbf{p}_1 \cdot \mathbf{p}_2 = |\mathbf{p}_1| |\mathbf{p}_2| \cos \theta$$
- Fixed point: if you use the  $[-1, 1]$  cube, it is the origin

# Virtual Trackball

- can we use the mouse to control the 2-D rotation of a viewing volume?
- imagine a track ball
  - user moves point on ball from  $(x, y, z)$  to  $(a, b, c)$
- imagine the points projected onto the ground
  - user moves point on ground from  $(x, 0, z)$  to  $(a, 0, c)$

# Trackball

- movement of points on track ball can be inferred from mouse drags on screen
- inverse problem
  - where on trackball does  $(a, 0, c)$  hit?
  - ball is unit sphere, so  $\|x, y, z\| = 1.0$
  - $x = a, z = c, y =$  solve for it

# Trackball

- user defines two points
  - place where first clicked  $X = (x, y, z)$
  - place where released  $A = (a, b, c)$
- ball rotates along axis perp to line defined by these two points
  - compute cross produce of lines to origin:  $(X - O) \times (A - O)$
- ball rotates by amount proportional to distance between lines
  - magnitude of cross product tells us angle between lines
    - (dot product too)
  - $|\sin \theta| = \frac{\| \text{cross product} \|}{\|X - O\| \|A - O\|}$
- compute rotation matrix and use it to rotate world