

Fall 2014

CSCI 420: **Computer Graphics**

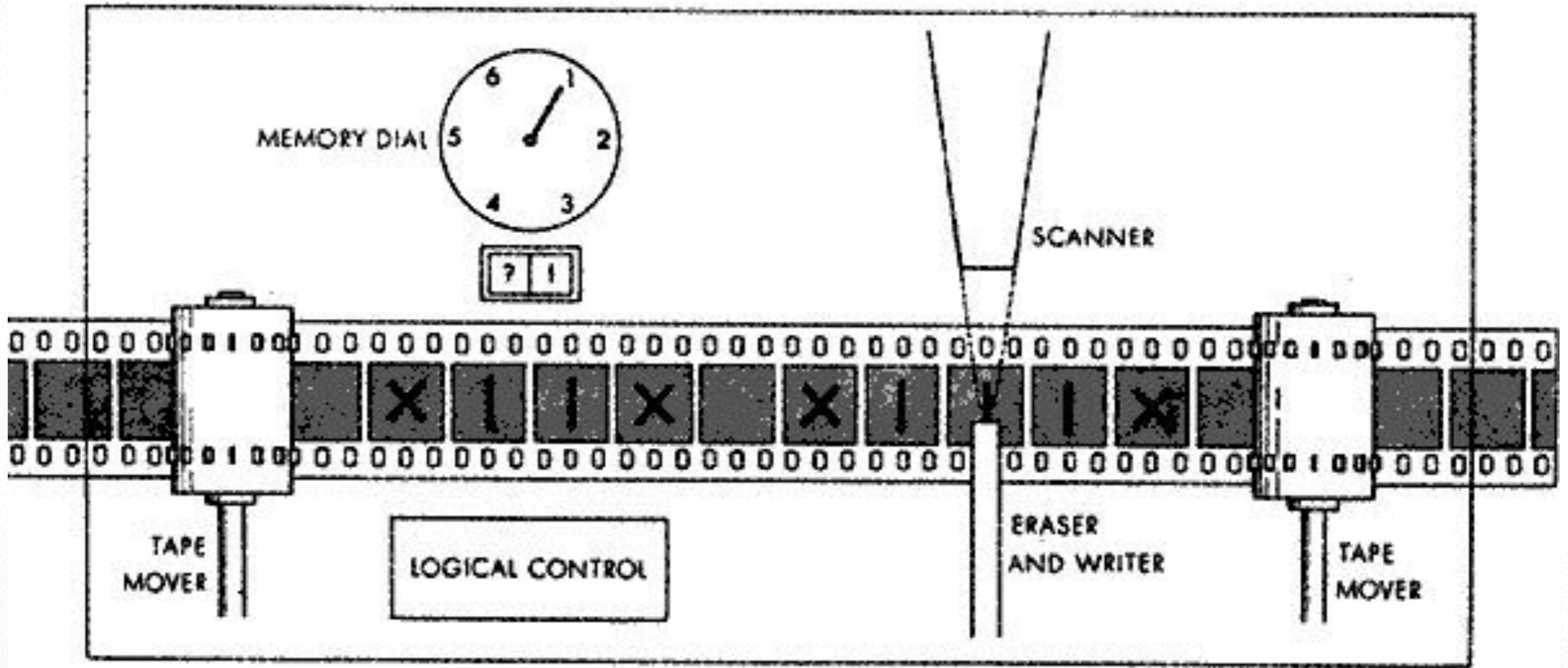
15.1 I/O Technologies & VR



Hao Li

<http://cs420.hao-li.com>

In CS I/O is an abstraction



<http://stackoverflow.com/questions/236000/whats-a-turing-machine>

In CG I/O is an object of study





- **Computer Graphics** and **Interactive Techniques**

Display Technologies

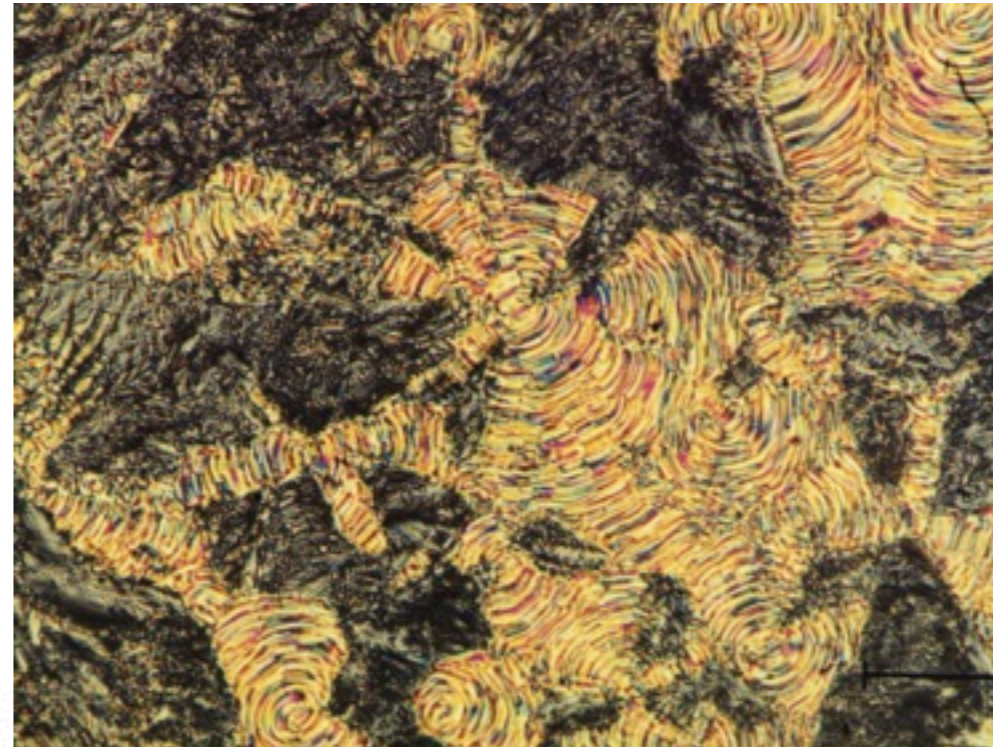
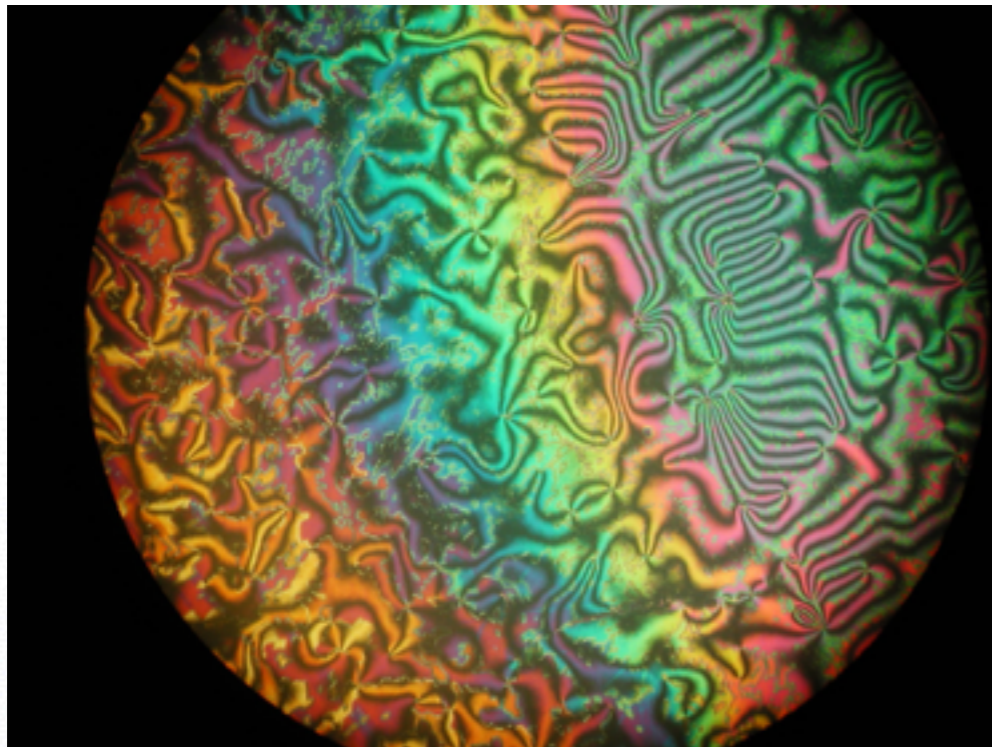


- **Liquid Crystal Display**

Liquid Crystals

- Matter in a state that has properties between liquid and solid crystals
- **Twisted nematics**

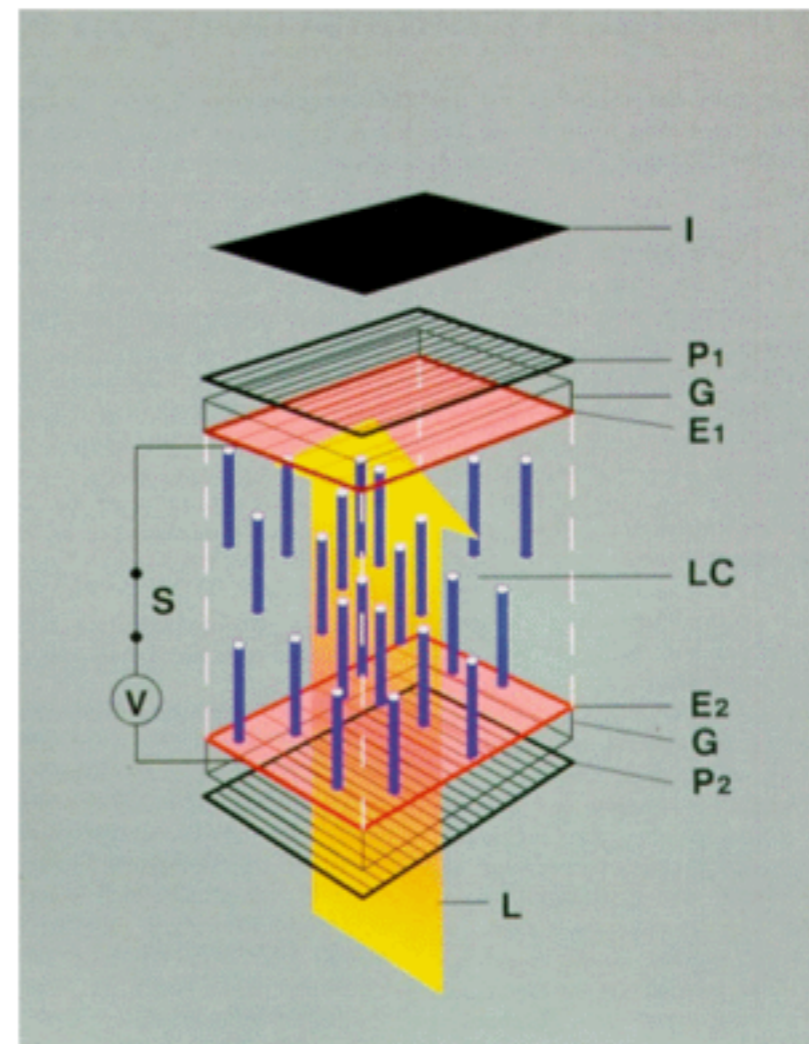
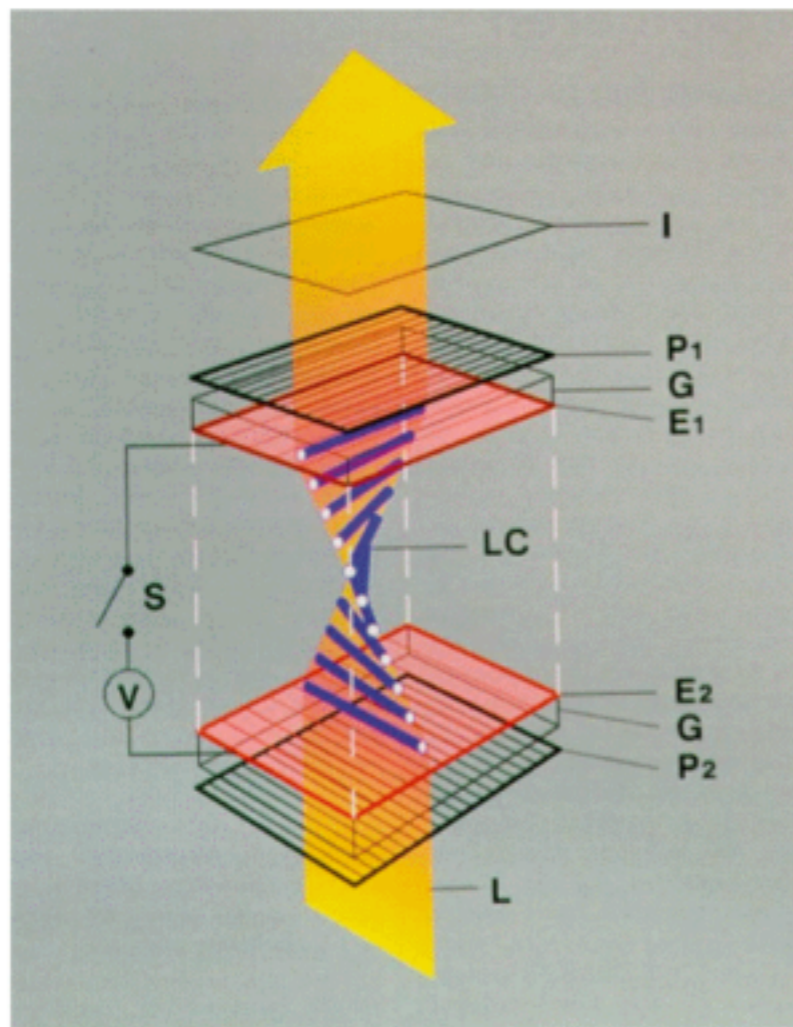
<http://mrsec.wisc.edu/Edetc/courses/colorsymp/park/index.html>



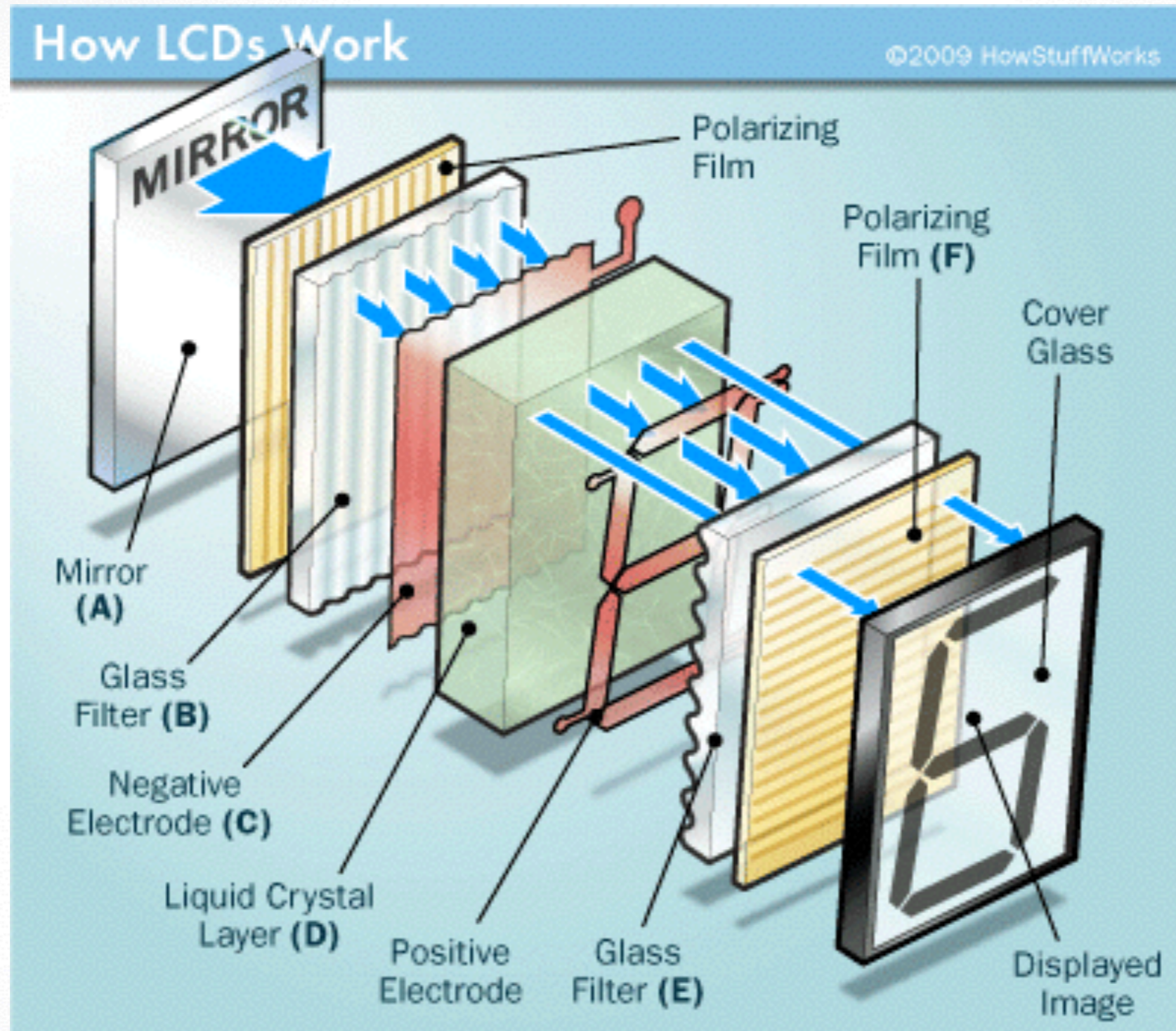
Anisotropic pattern depending on electricity, heat, etc.

Liquid Crystals

- Off-state (left), On-state (right)

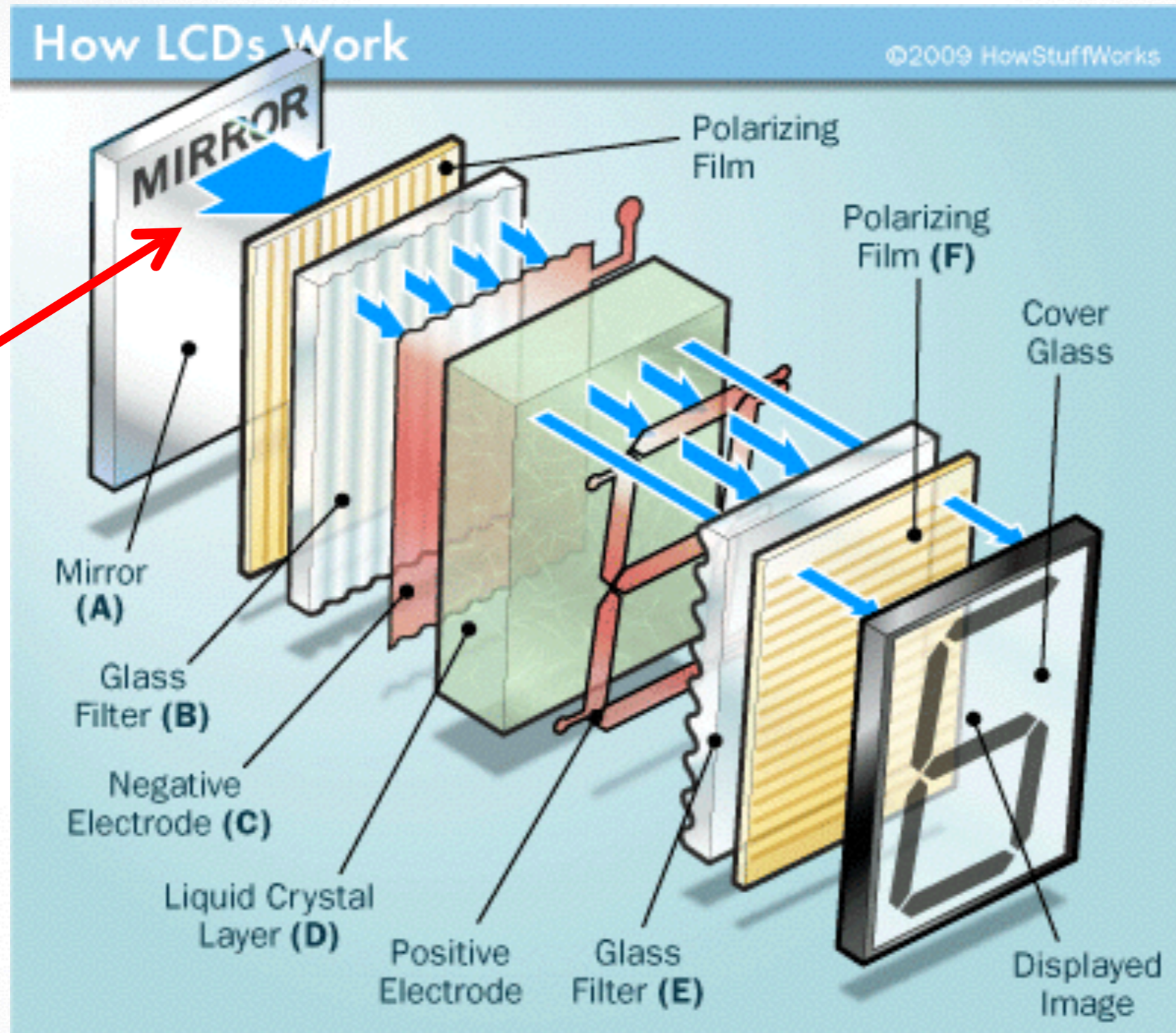


LCD Light Path

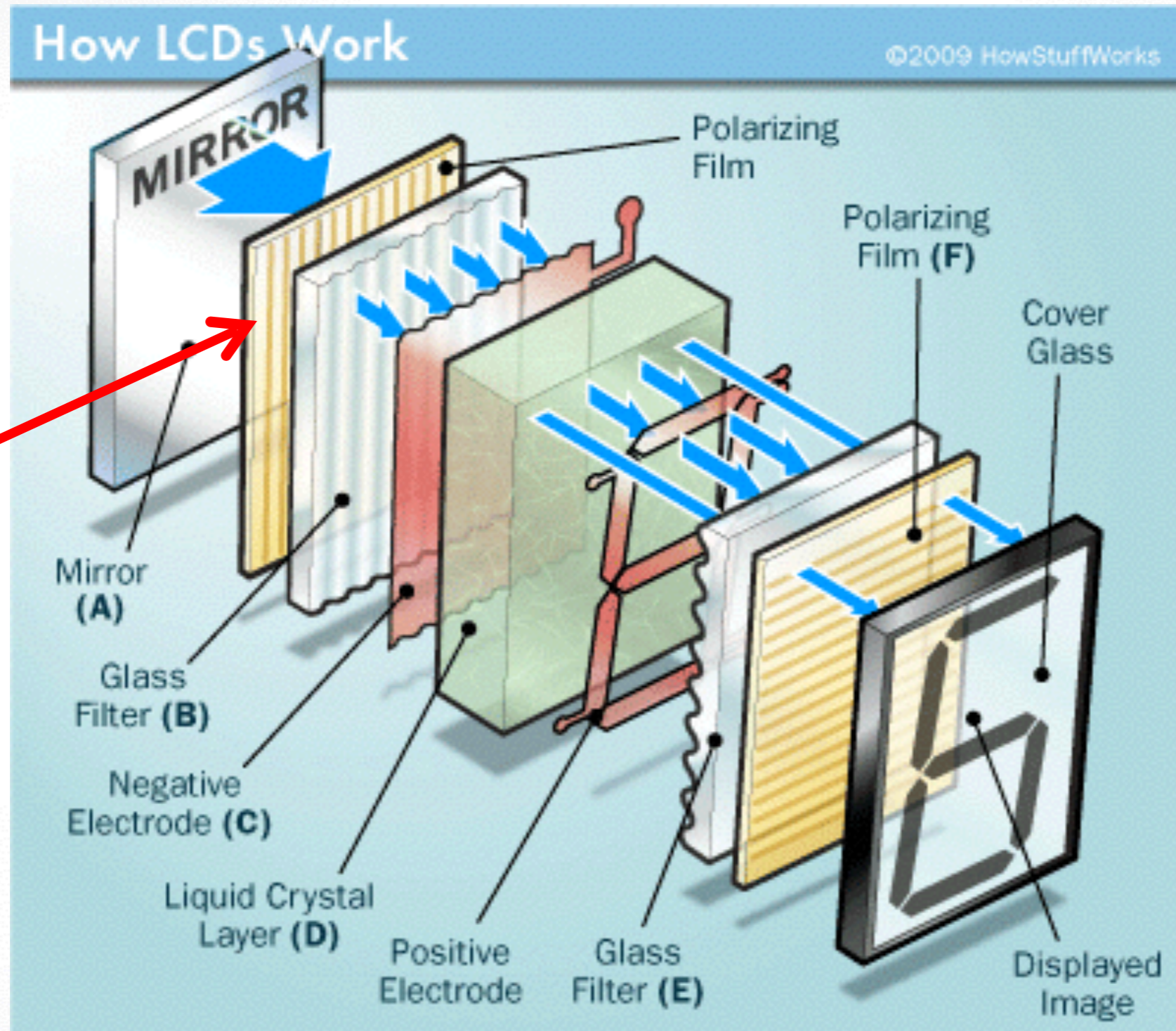


LCD Light Path

Light Source

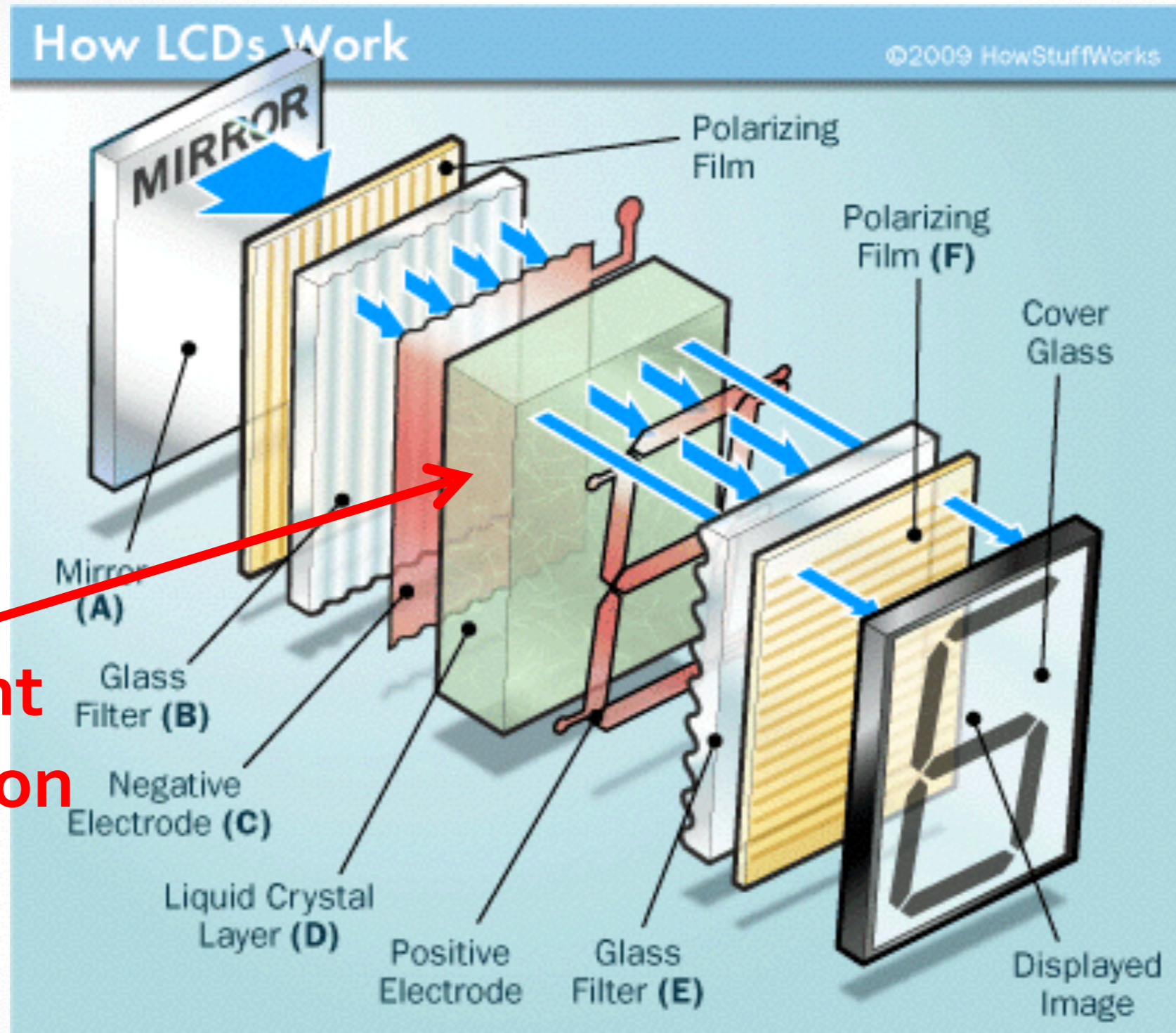


LCD Light Path



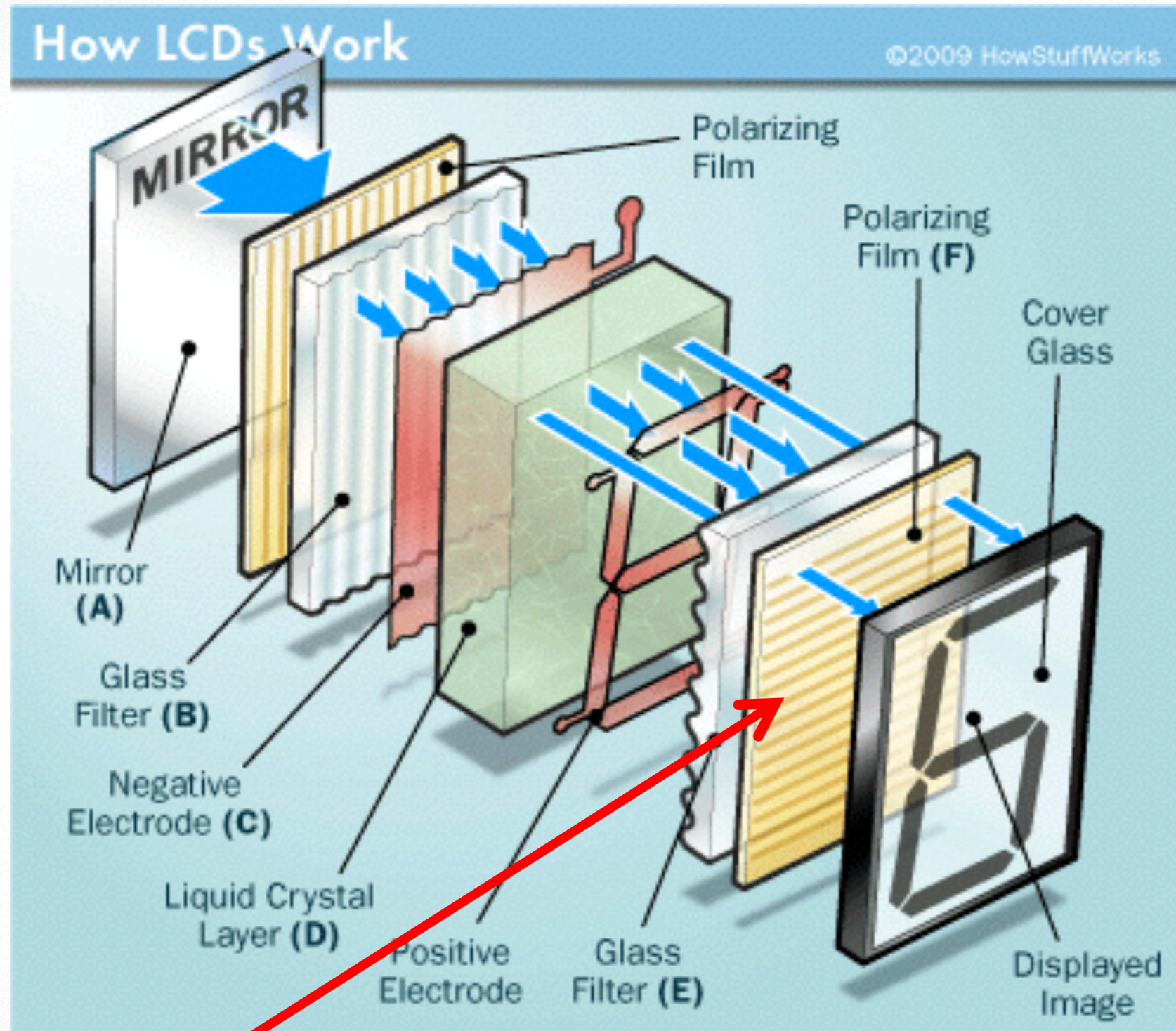
Polarize

LCD Light Path



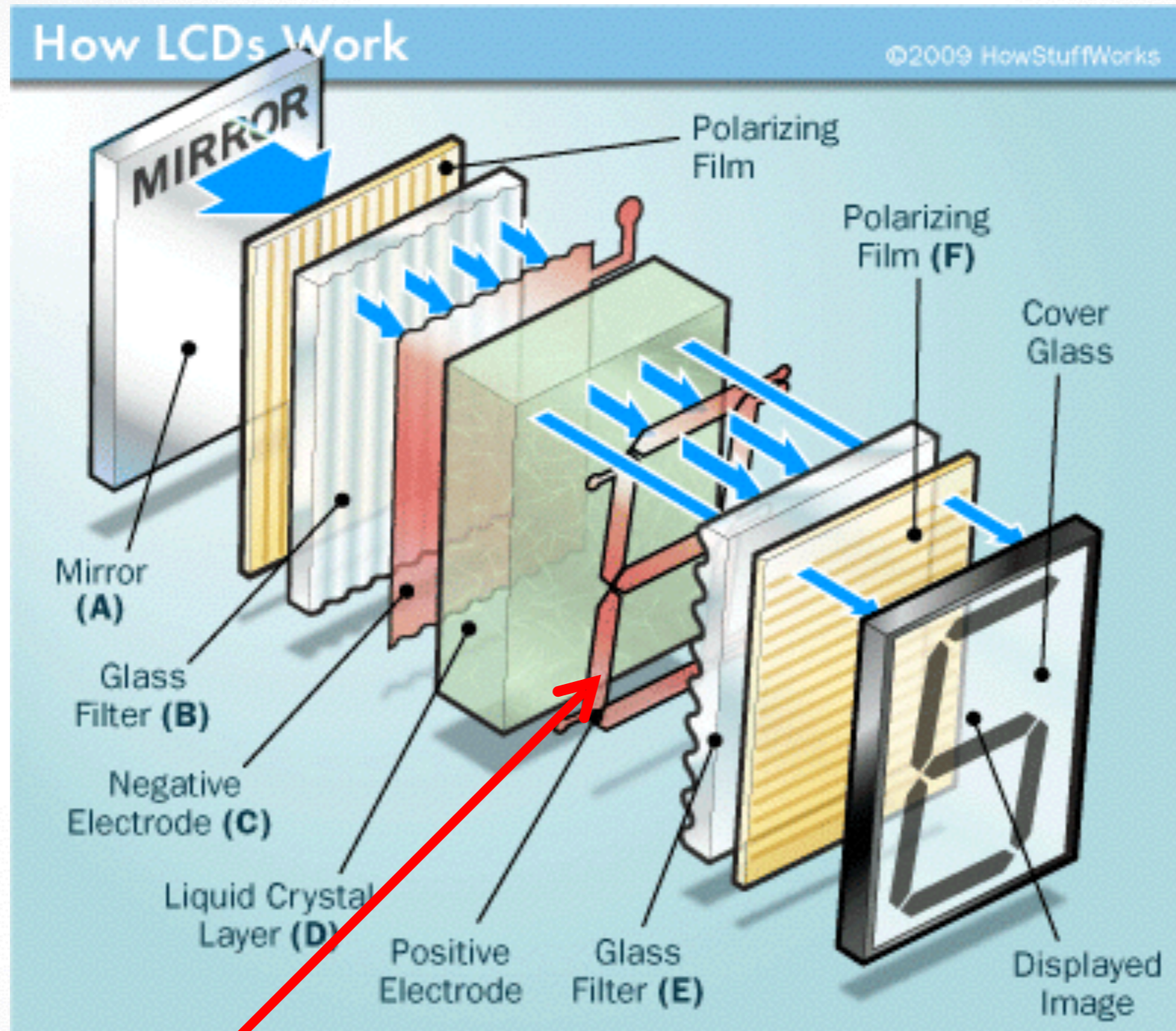
Twist Light
Polarization

LCD Light Path



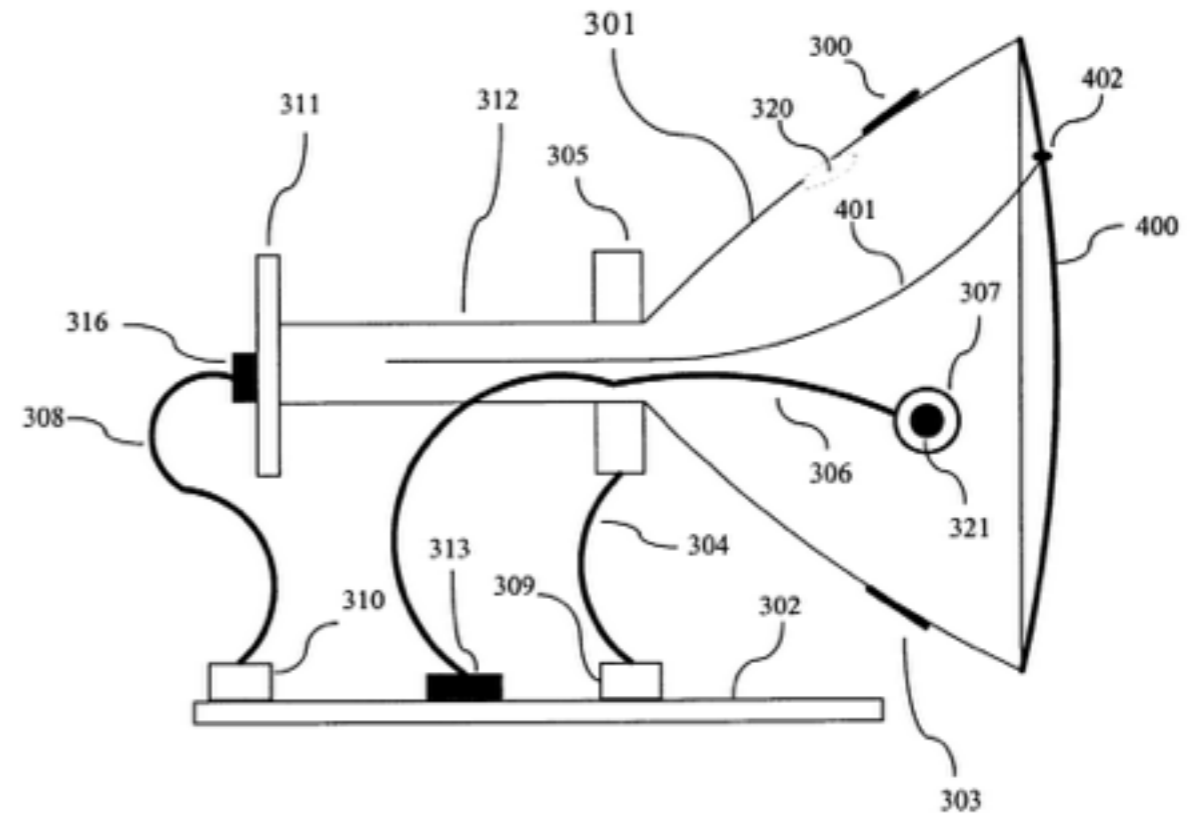
Only twisted light makes it through

LCD Light Path



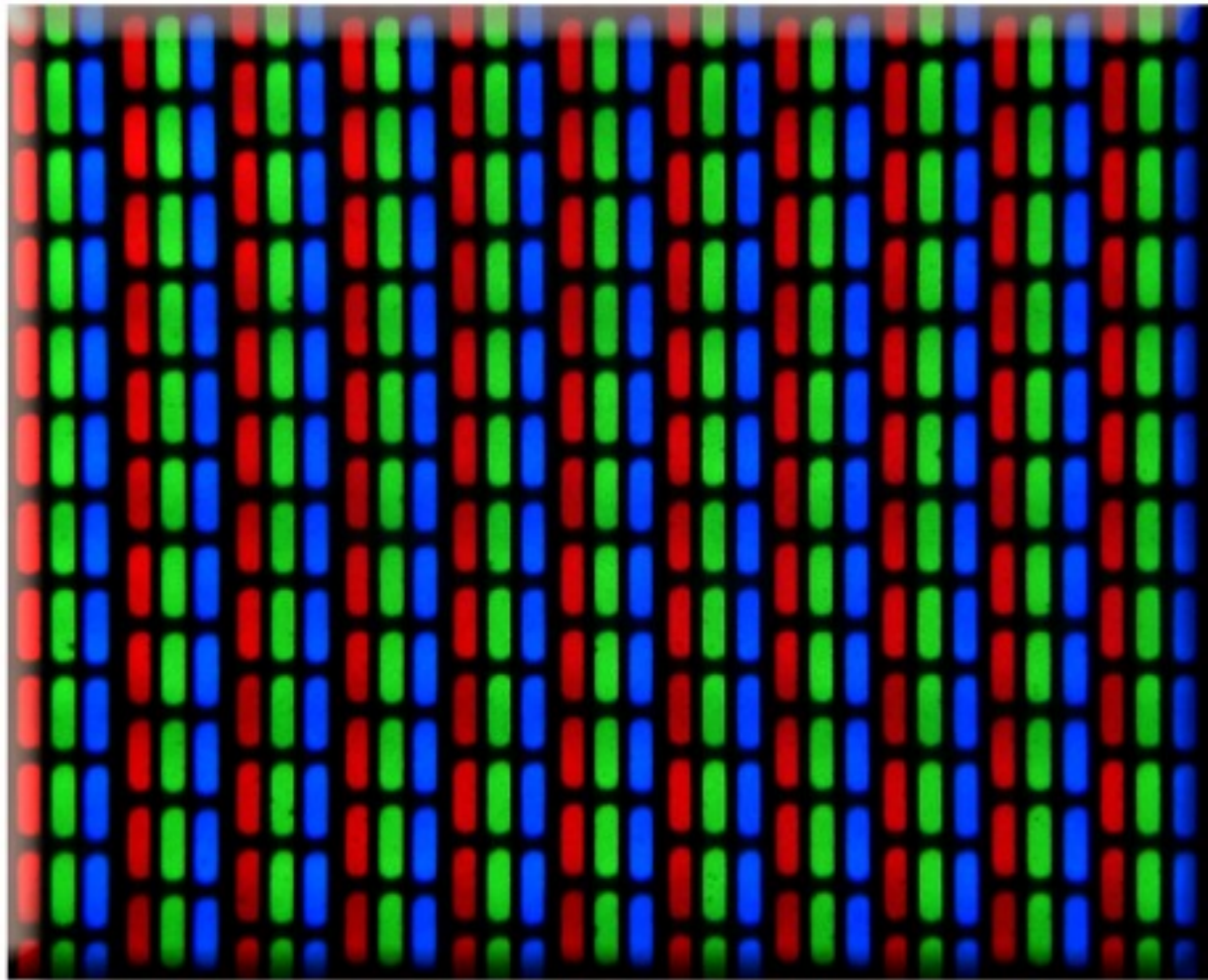
Electrode controls crystals

Cathode Ray Tube (CRT)

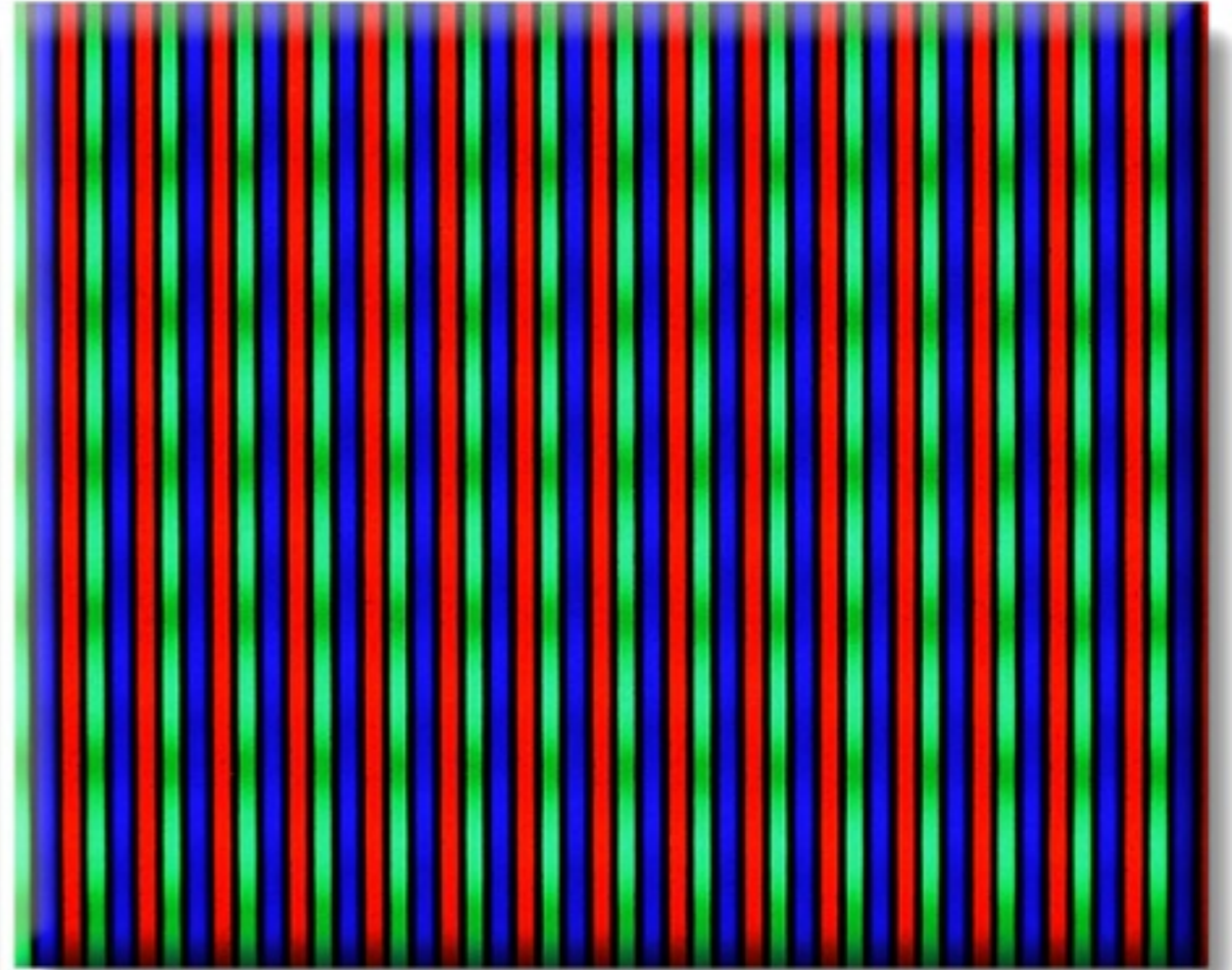


http://img.diytrade.com/cdimg/597243/7515356/0/1276139831/Sell_CRT_Monitor.jpg
<http://www.freepatentsonline.com/6741296-o-large.jpg>

Practical Display Issues

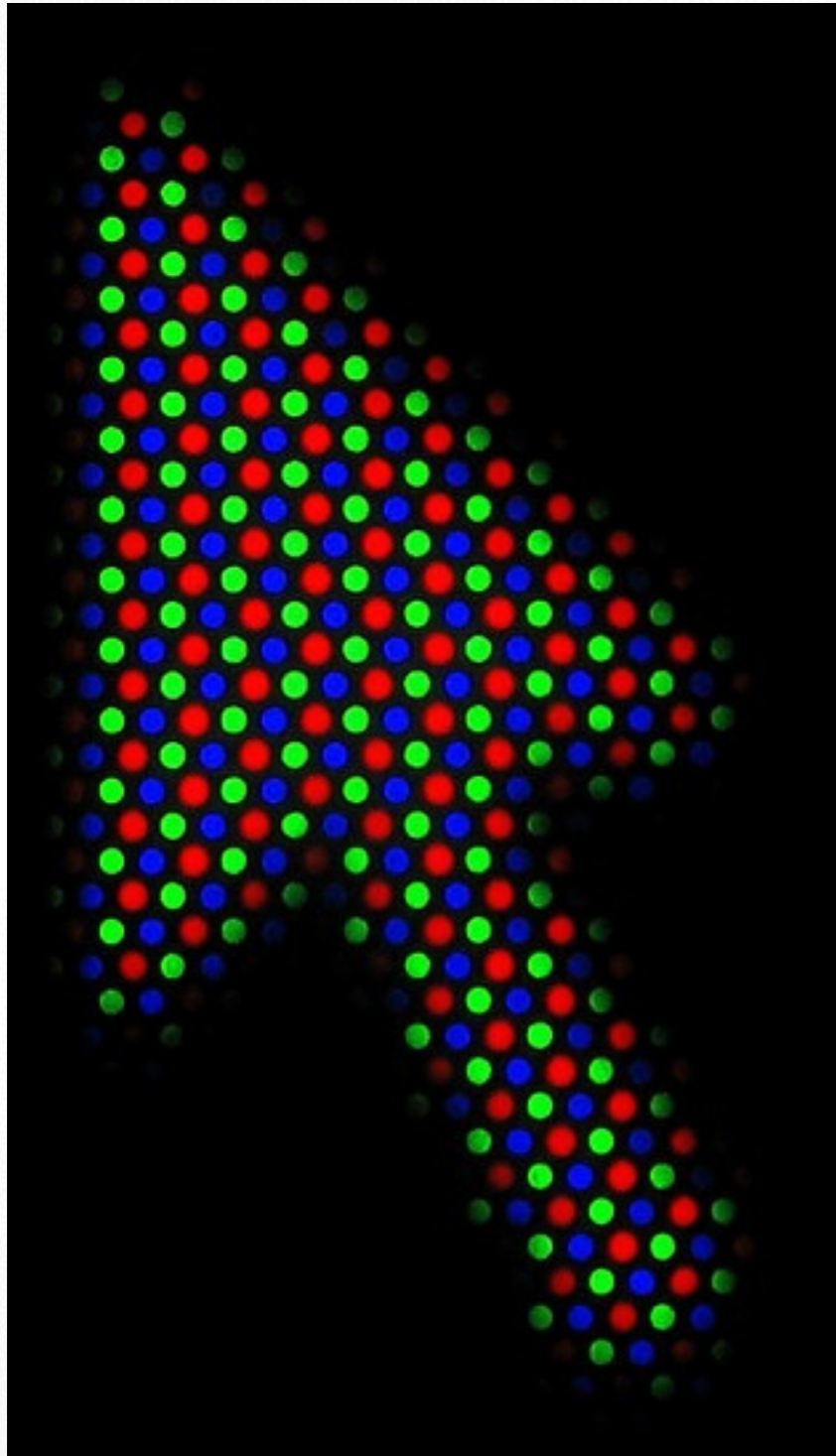


Shadow Mask



Aperture Grille

Practical Display Issues

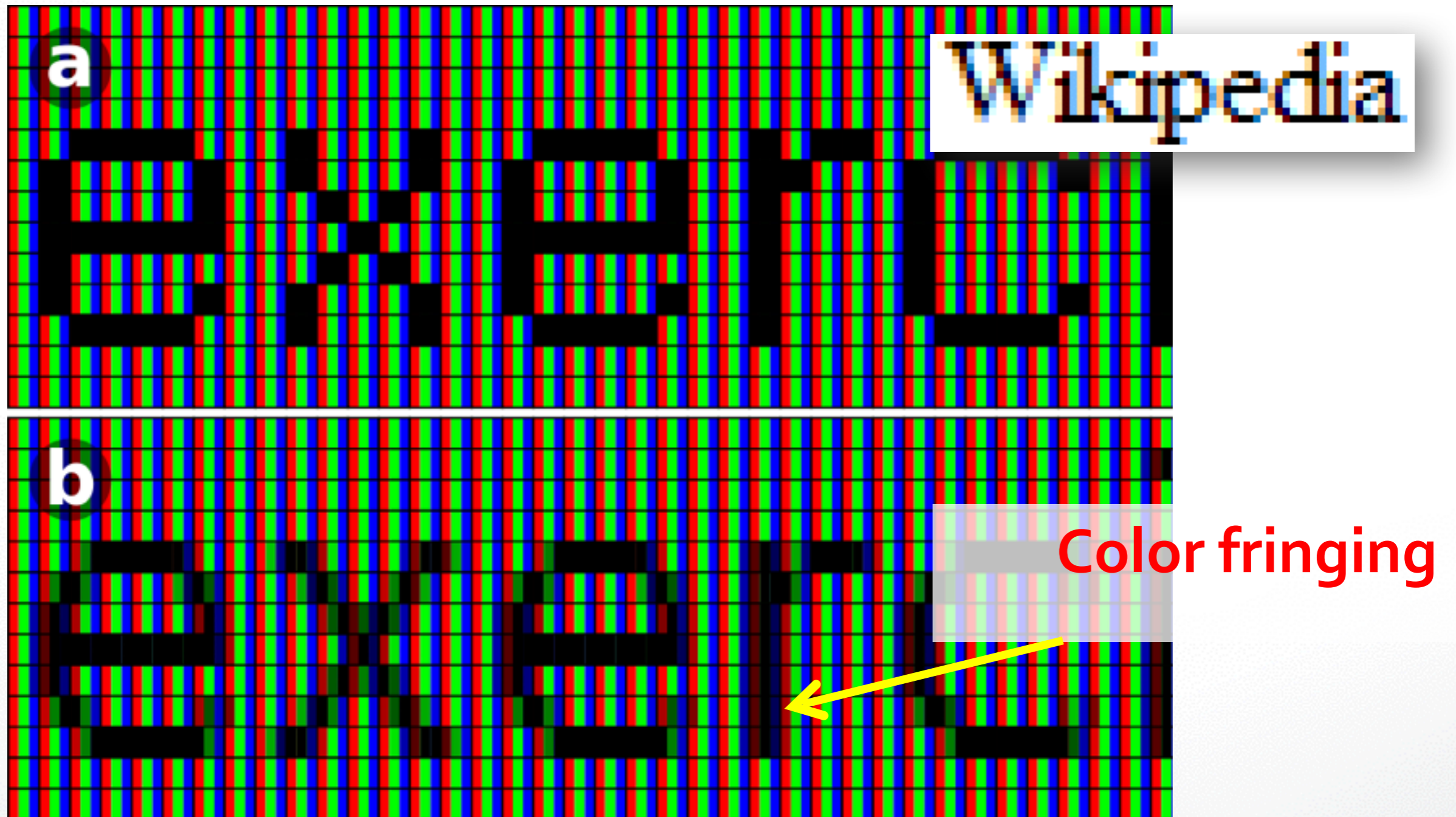


http://en.wikipedia.org/wiki/File:Shadow_mask_closeup_cursor.jpg

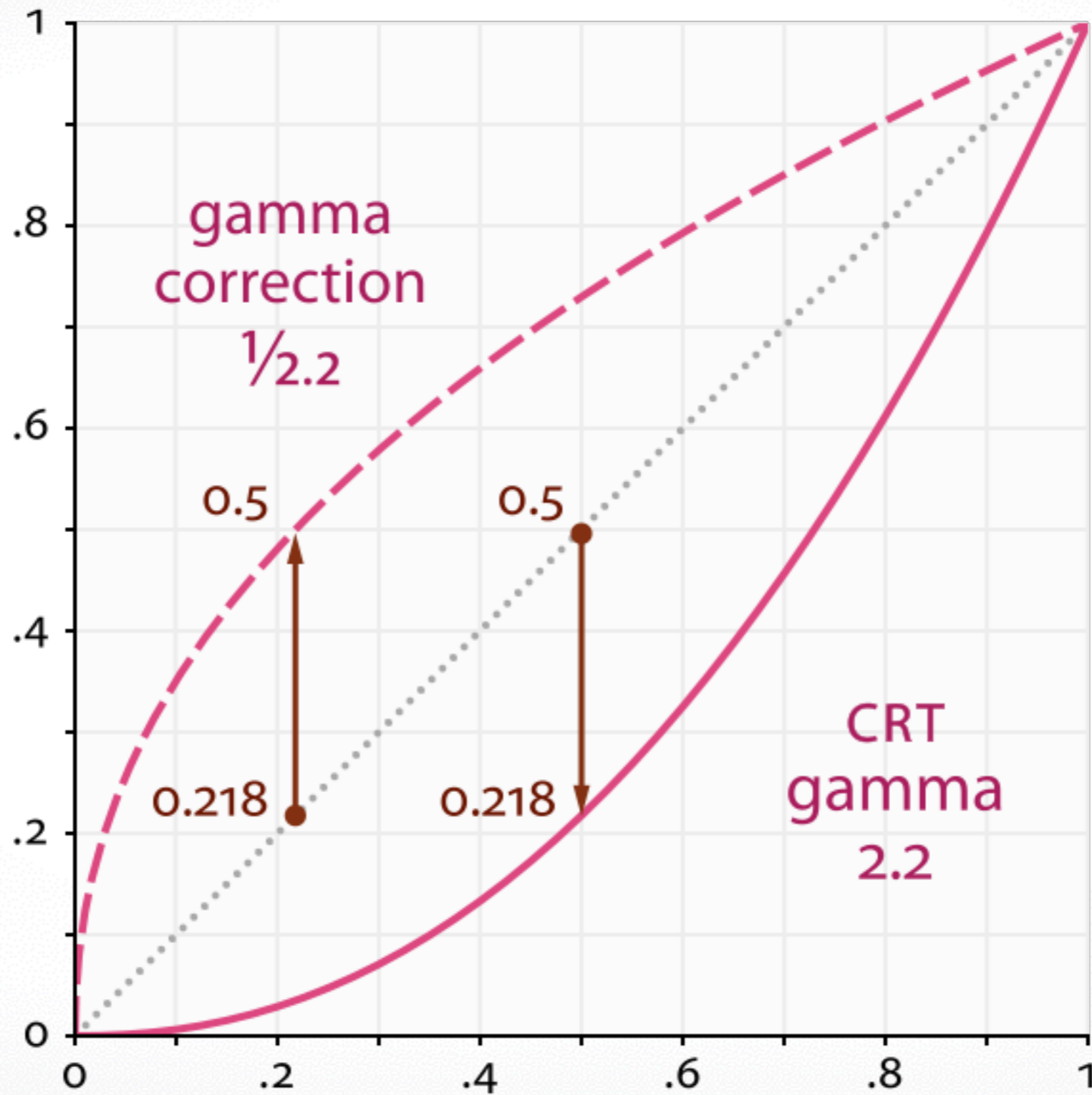
Have to convert from
RGB to display pattern

Subpixel Antialiasing

- Clear Type (Microsoft, 1998), subpixel rendering



Practical Display Issues



Practical Display Issues

Nonlinear relationship between brightness and intensity

Perceptual



Display-related



Practical Display Issues

Nonlinear relationship between brightness and intensity

Nonlinear relationship between intensity and hardware response

Gamma Model: For Displays

$$\text{displayed intensity} = (\text{maximum intensity})a^\gamma$$

Pixel color

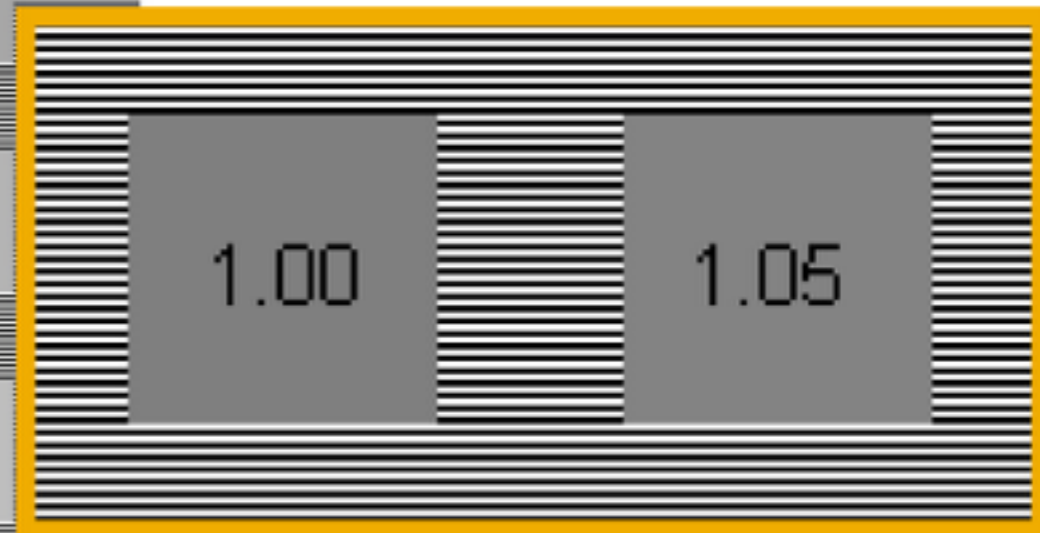


Gamma Model: For Displays

$$\text{displayed intensity} = (\text{maximum intensity})a^\gamma$$

Monitor Gamma Estimator

1.00	1.05	1.10	1.15	1.20	1.25	1.30
1.35	1.40	1.45	1.50	1.55	1.60	1.65
1.70	1.75	1.80	1.85	1.90	1.95	2.00
2.05	2.10	2.15	2.20	2.25	2.30	2.35
2.40	2.45	2.50	2.55	2.60	2.65	2.70



http://www.kenluckephoto.com/portfolio/monitoradjust/files/page17_2.gif

Gamma Model: For Displays

$$\text{displayed intensity} = (\text{maximum intensity})a^\gamma$$

$$0.5 = a^\gamma \mapsto \gamma = \frac{\ln 0.5}{\ln a}$$

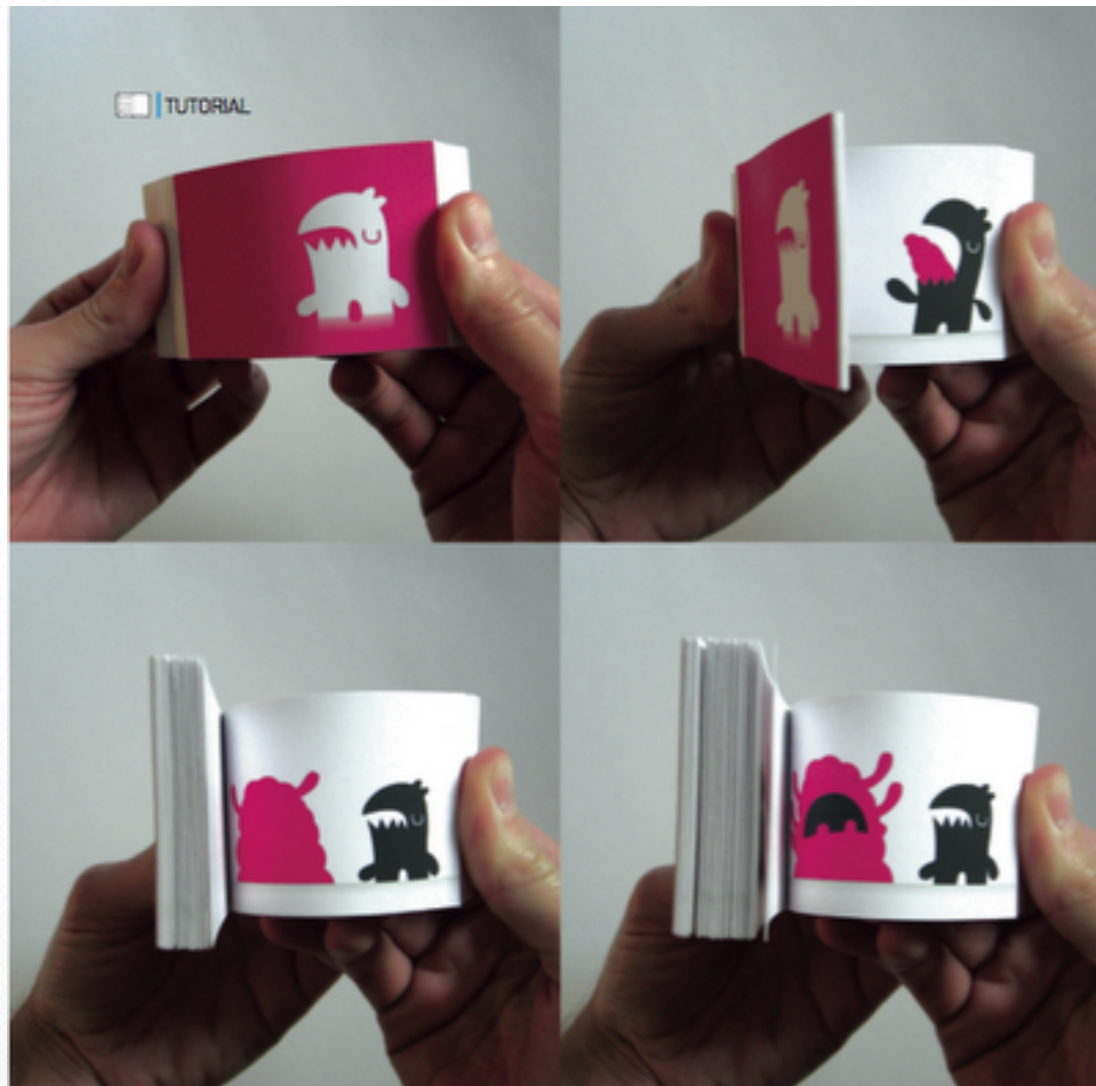
Why don't we do this always?

Gamma and perceptual
differences in brightness **cancel!**

...approximately

Detecting/Processing Motion

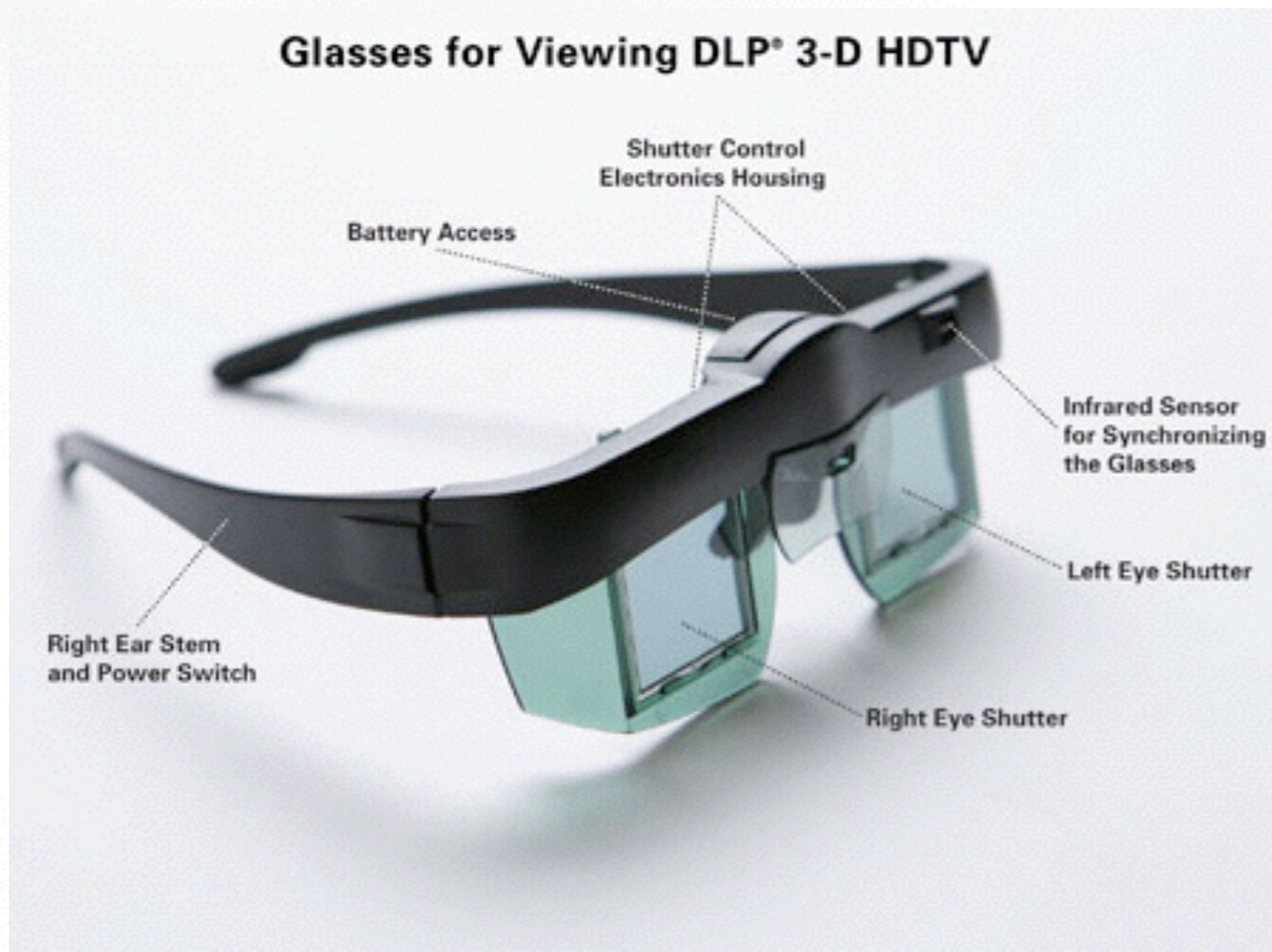
Visual sensors must communicate!



Discontinuous motion with same average velocity as implied **continuous motion**.

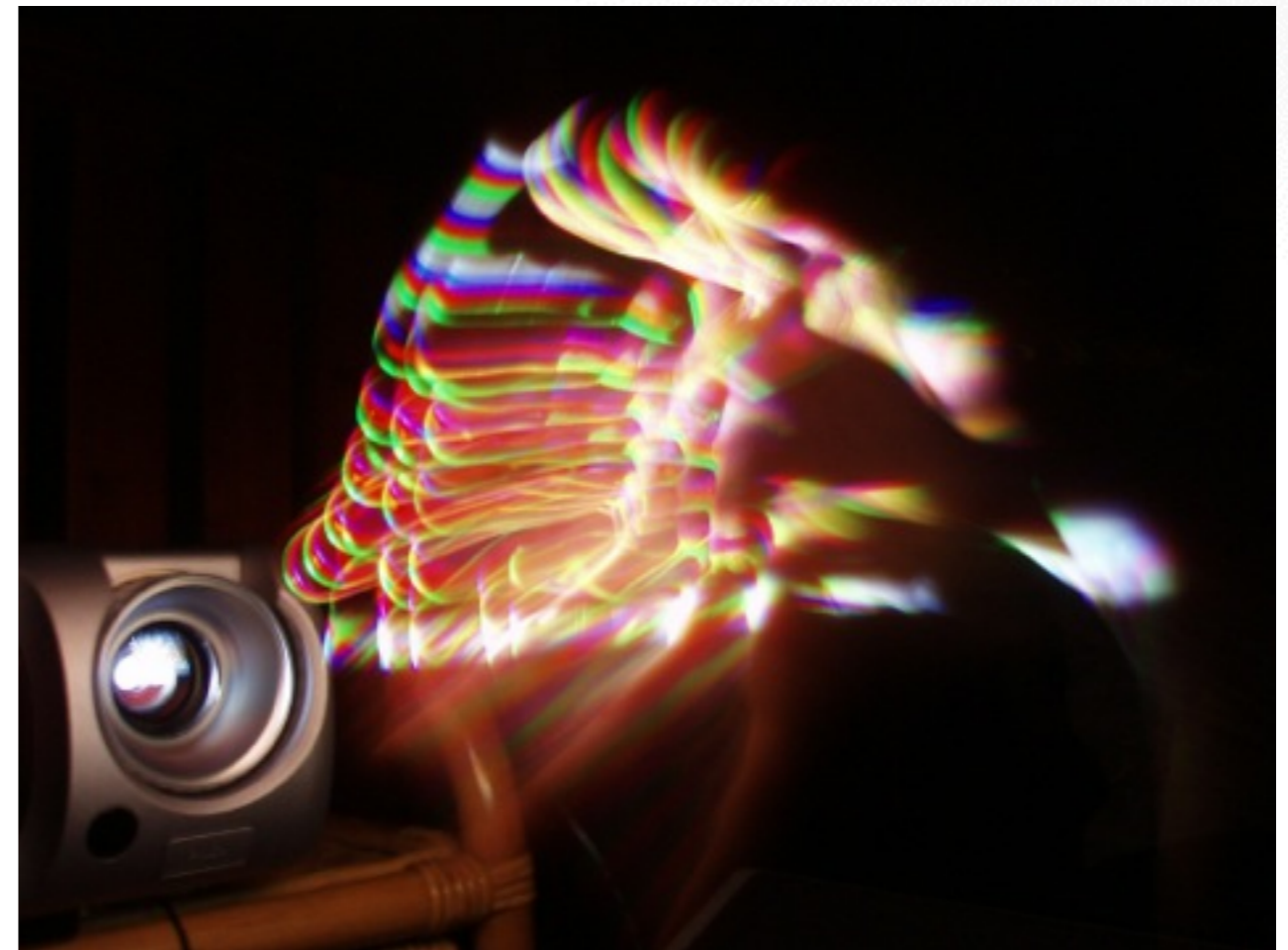
Other Displays

Glasses for Viewing DLP® 3-D HDTV



LCD Shutter

Alternate between eyes



Digital Light Processing (DLP)

Spinning color wheel

Other Displays



Four primaries!



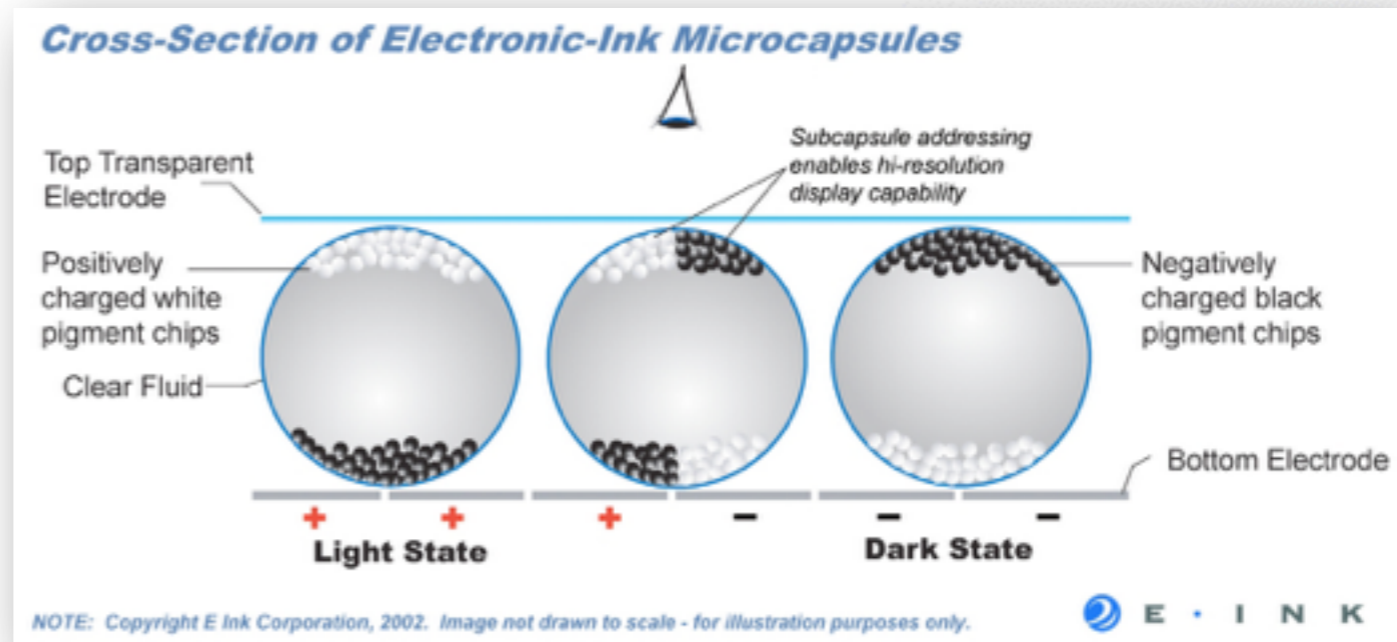
No black



Max black

http://en.wikipedia.org/wiki/CMYK_color_model

Other Displays



Electronic ink

Different appearance, slow update rate

Dealing with Input

■ Events

Notify when state changes

■ Polling

Check for changed state

Events



Efficient



Need to track state
Need to decide on events of interest

Polling

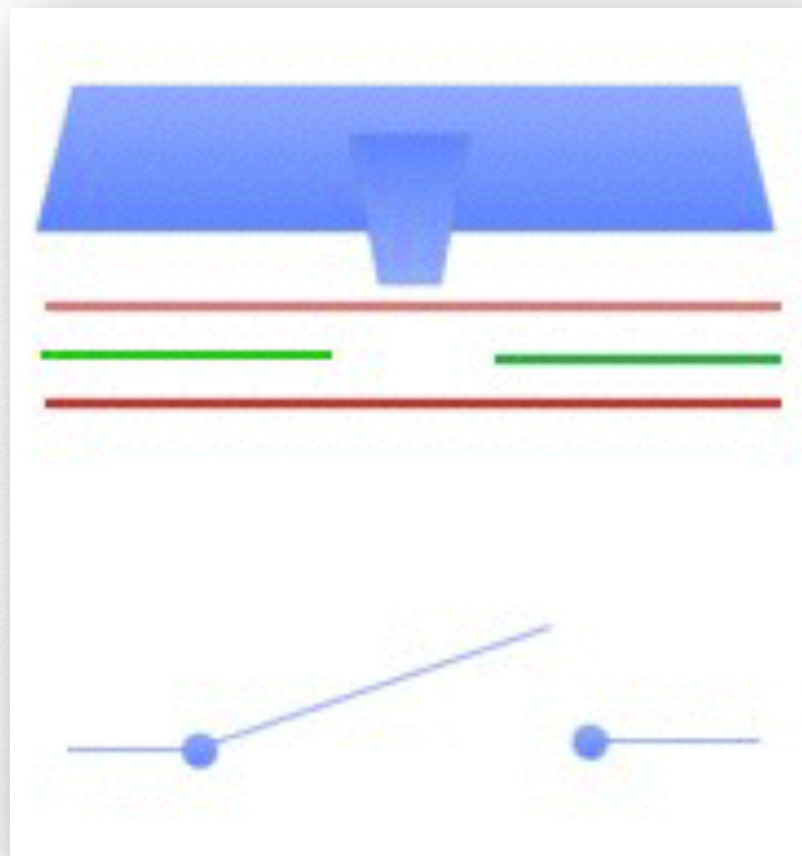
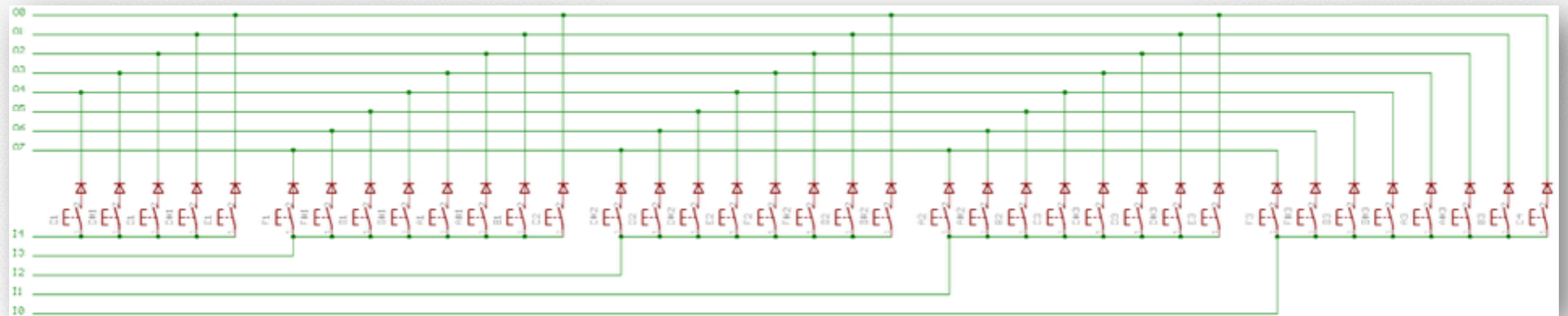


Cleanly deals with continuous state change



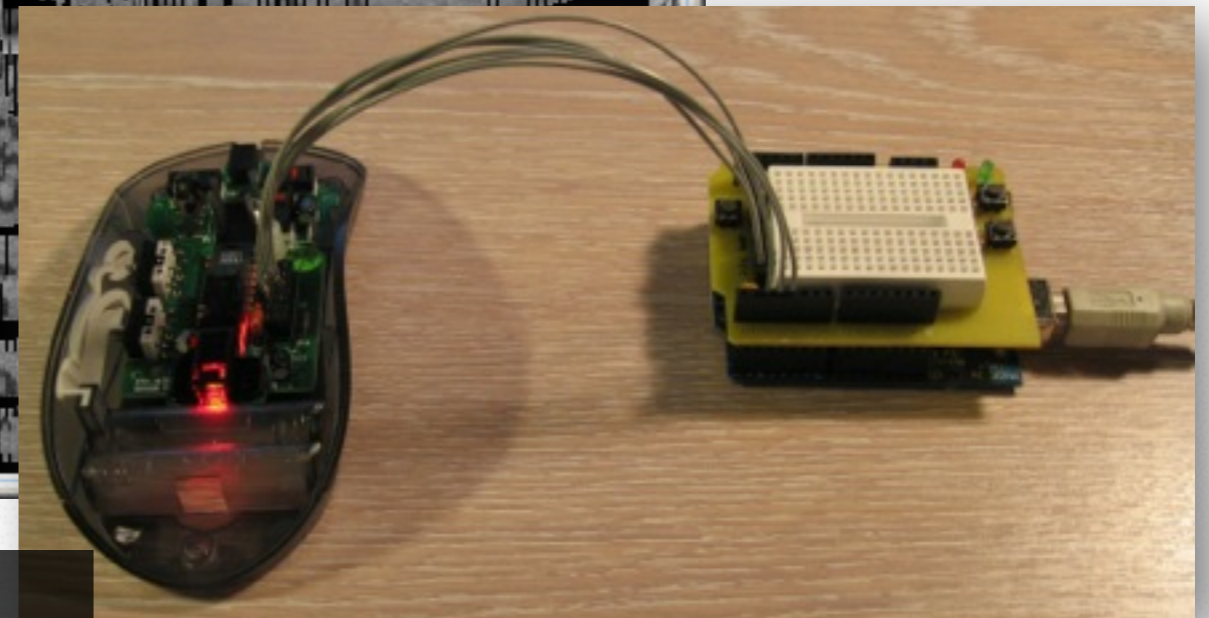
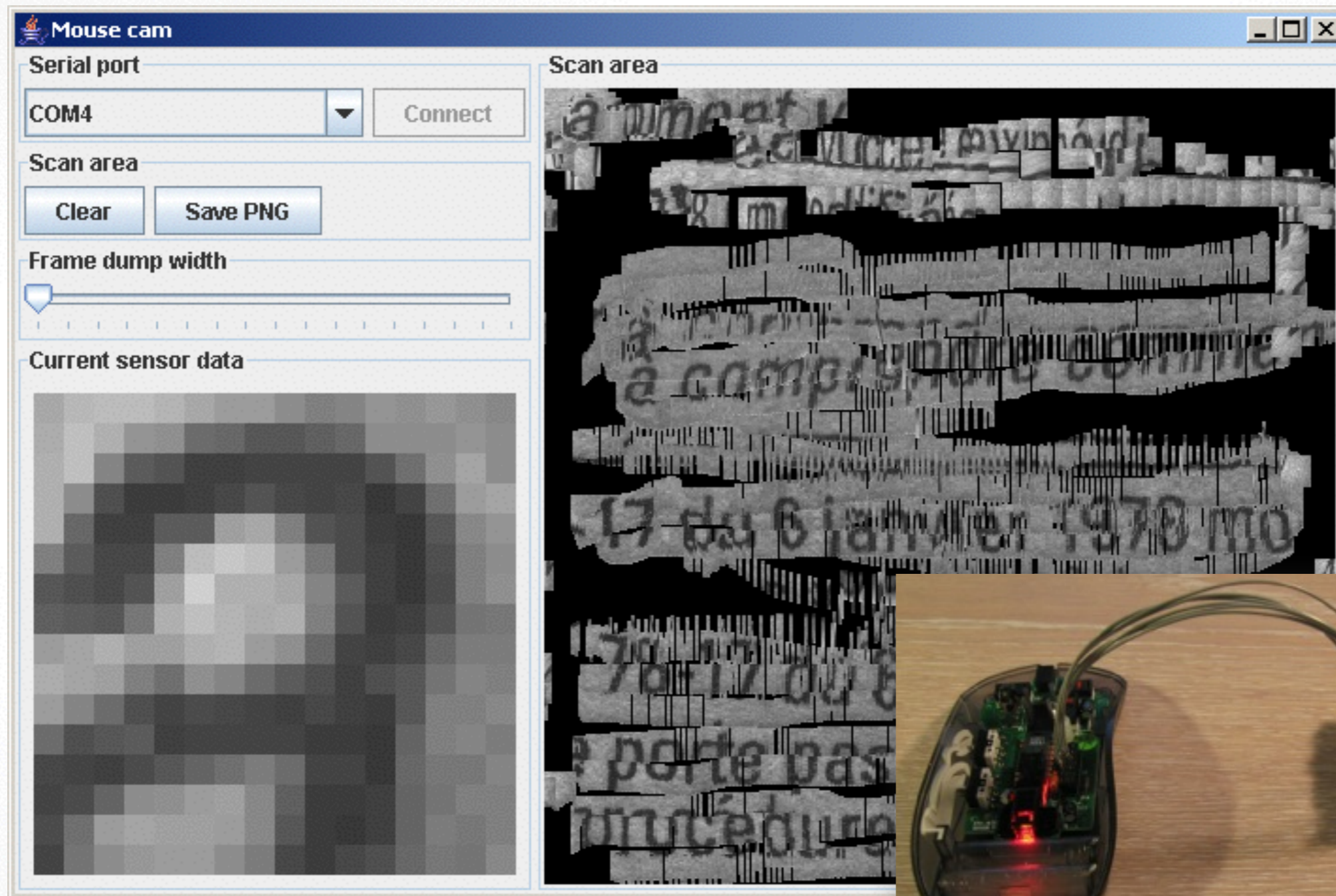
**Could miss a state change
Considerable overhead**

Keyboards



Key press closes circuit;
character map used to
determine which key (filter
bounces)

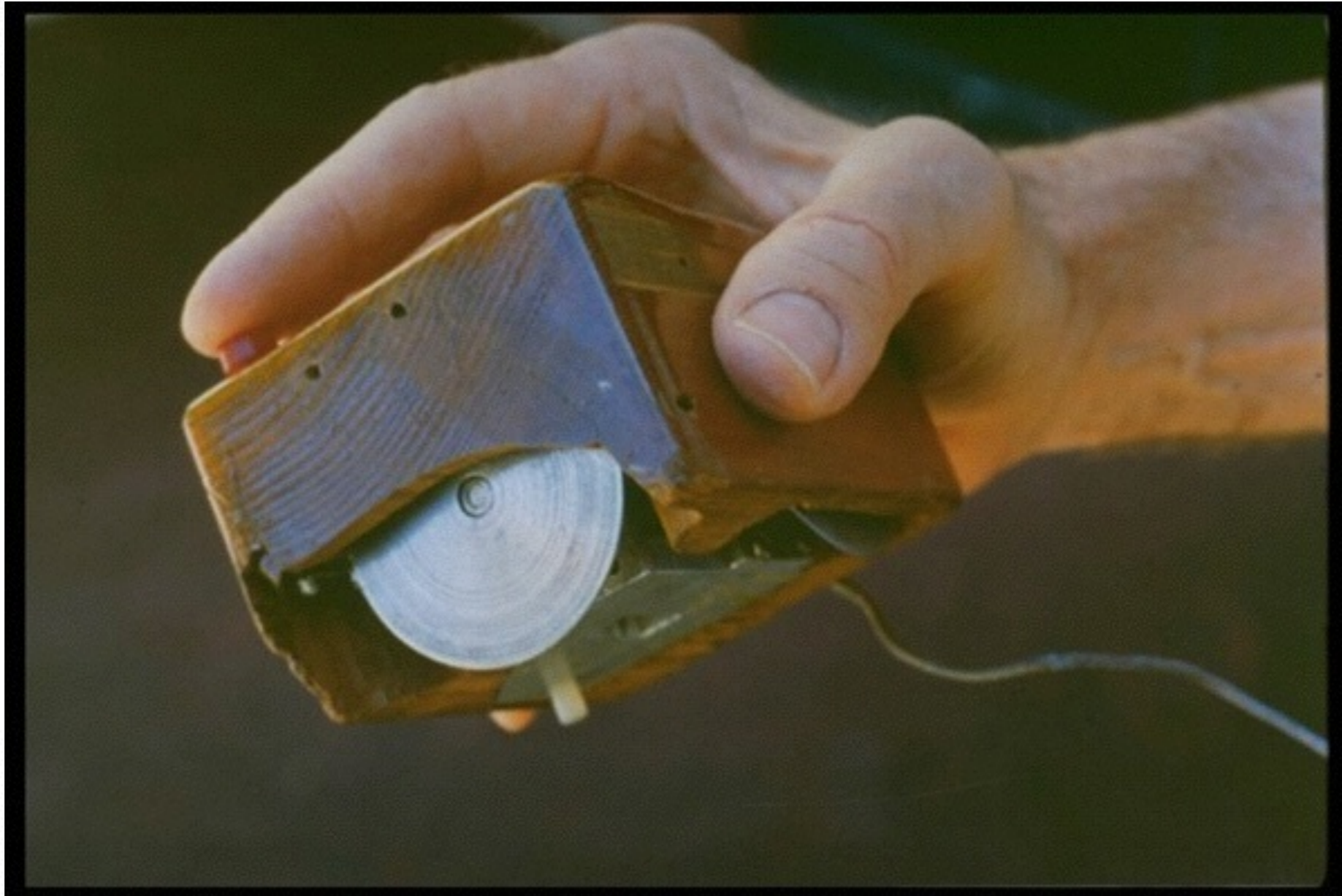
Optical Mice



Digital Image Correlation

<http://www.bidouille.org/hack/mousecam>

Optical Mouse



<http://www.blogcdn.com/www.engadget.com/media/2008/12/original-mouse-08deco3.jpg>

Multitouch



DIY tables

Frustrated total internal reflection, direct illumination

iPod/iPad/Perceptive Pixel

Capacitive surface

Cheaper alternatives

Pressure

<http://www.xda-developers.com/wp-content/uploads/2011/09/multitouch-gesture-on-iphone-ipad-and-ipod.jpg?139d23>

<http://www.talkandroid.com/wp-content/uploads/2011/09/ipad-multi-touch.jpg?3995d3>

Other Input Sources



Game controller, joystick

Communicate with station



Wii remote

Accelerometers, IR sensor

<http://o.tqn.com/d/compactiongames/1/0/J/A/1/gp2.jpg>
<https://images-na.ssl-images-amazon.com/images/G/01/videogames/detail-page/Boo45FGET2.01.lg.jpg>

Other Input Sources



Camera



Kinect

Other Input Sources



<http://www.cyberware.com/products/scanners/lss.html>
http://home.12move.nl/~sh290334/dbase_force/cybergrasp.jpg
http://upload.wikimedia.org/wikipedia/commons/1/13/Rosies_ct_scan.jpg
http://www.nemusiccenter.com/product_images/u/377/SM58__69613_zoom.jpg
<http://onemillionlyrics.com/lyrics/scanner/rmu>
<http://bssdigitalsound.files.wordpress.com/2008/02/midi-mk249c.jpg>

Virtual Reality



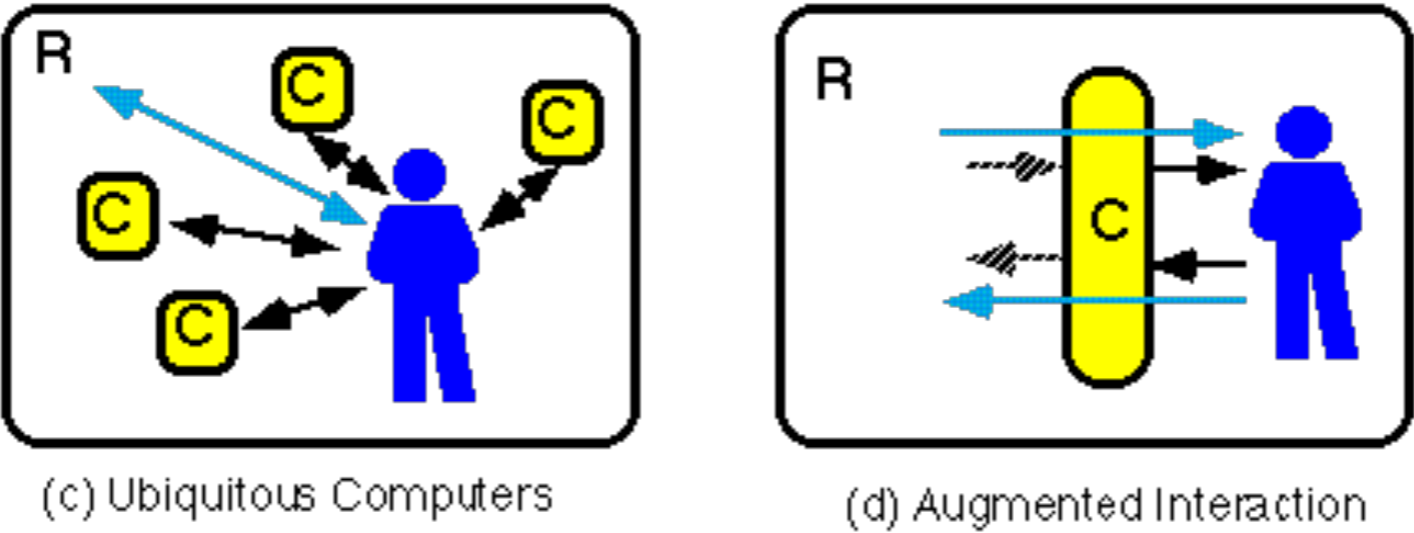
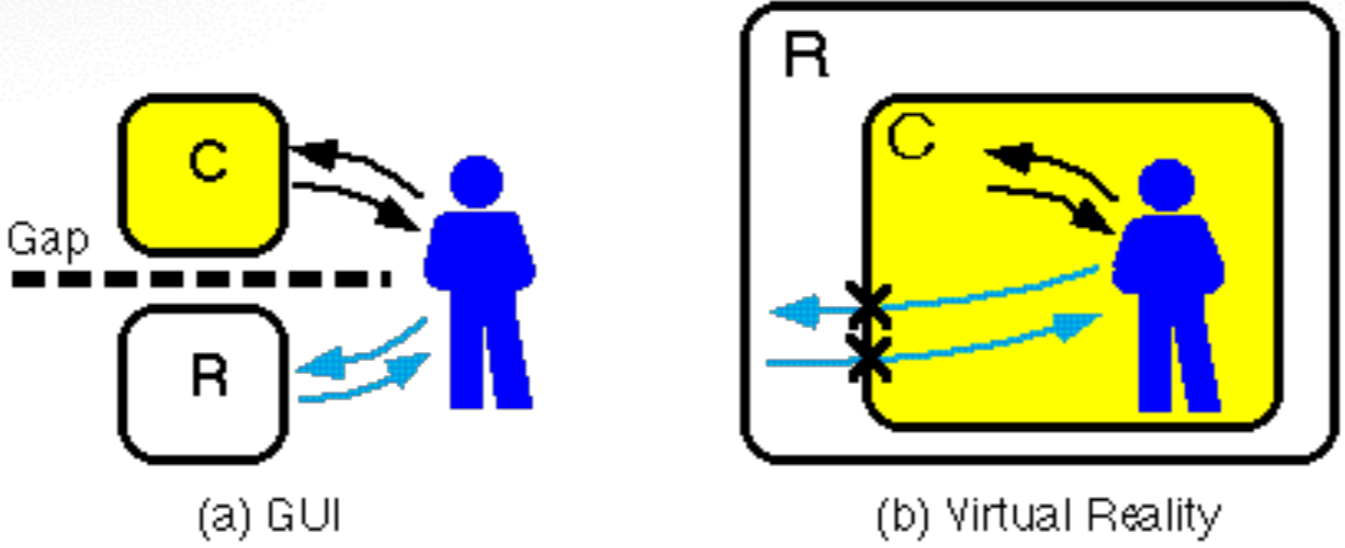
Technological Trends

- Smaller, cheaper, more functions, more intimate, **more immersive**

Technology becomes invisible

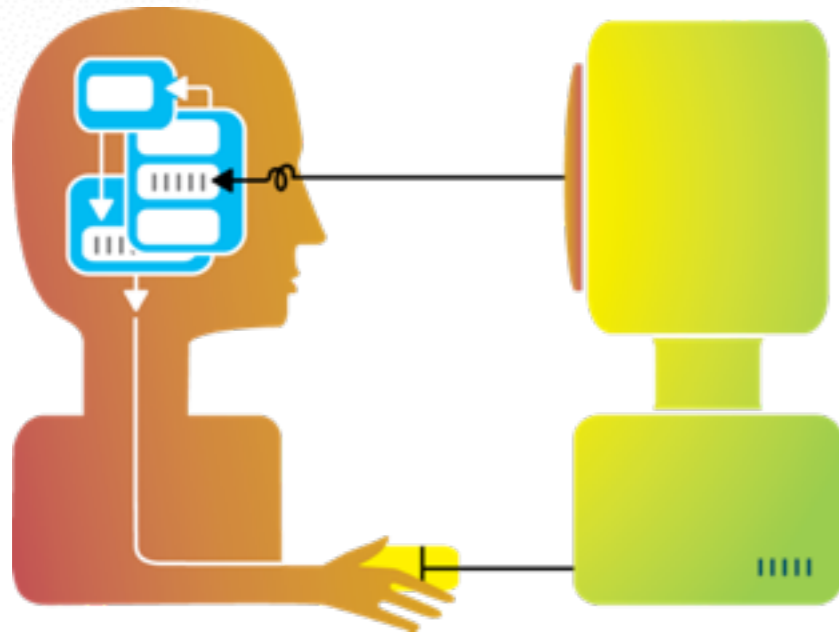
- Intuitive to use
- Interface over internals
- Form over function
- Human centered design

Invisible Interfaces



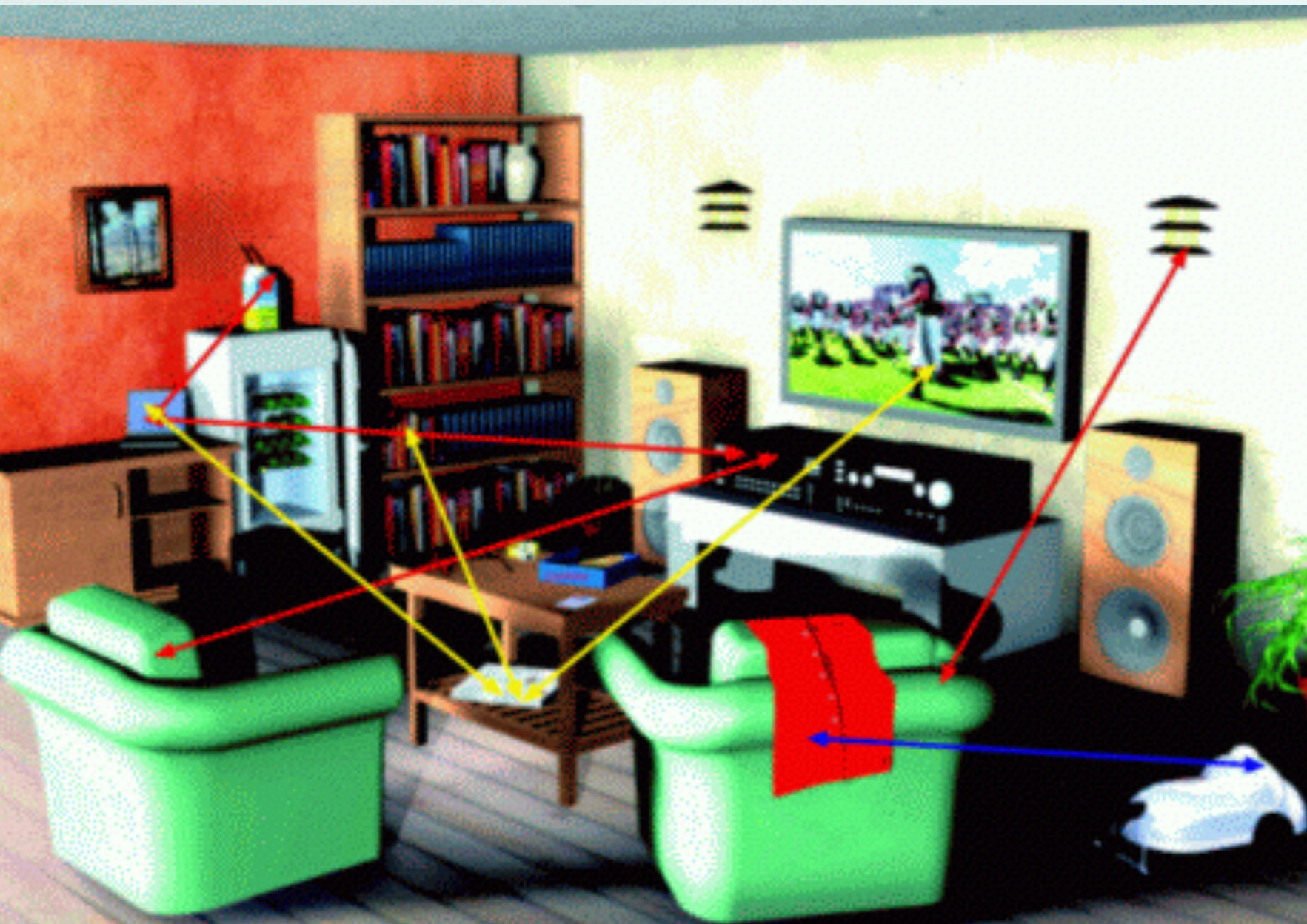
- Computer World
- Real World
- Human - Computer Interaction
- Human - Real World Interaction
- Real World - Computer Interaction

Graphical User Interfaces



- Separation between real and digital worlds
- WIMP (Windows Icons, Menus, Pointer) metaphor

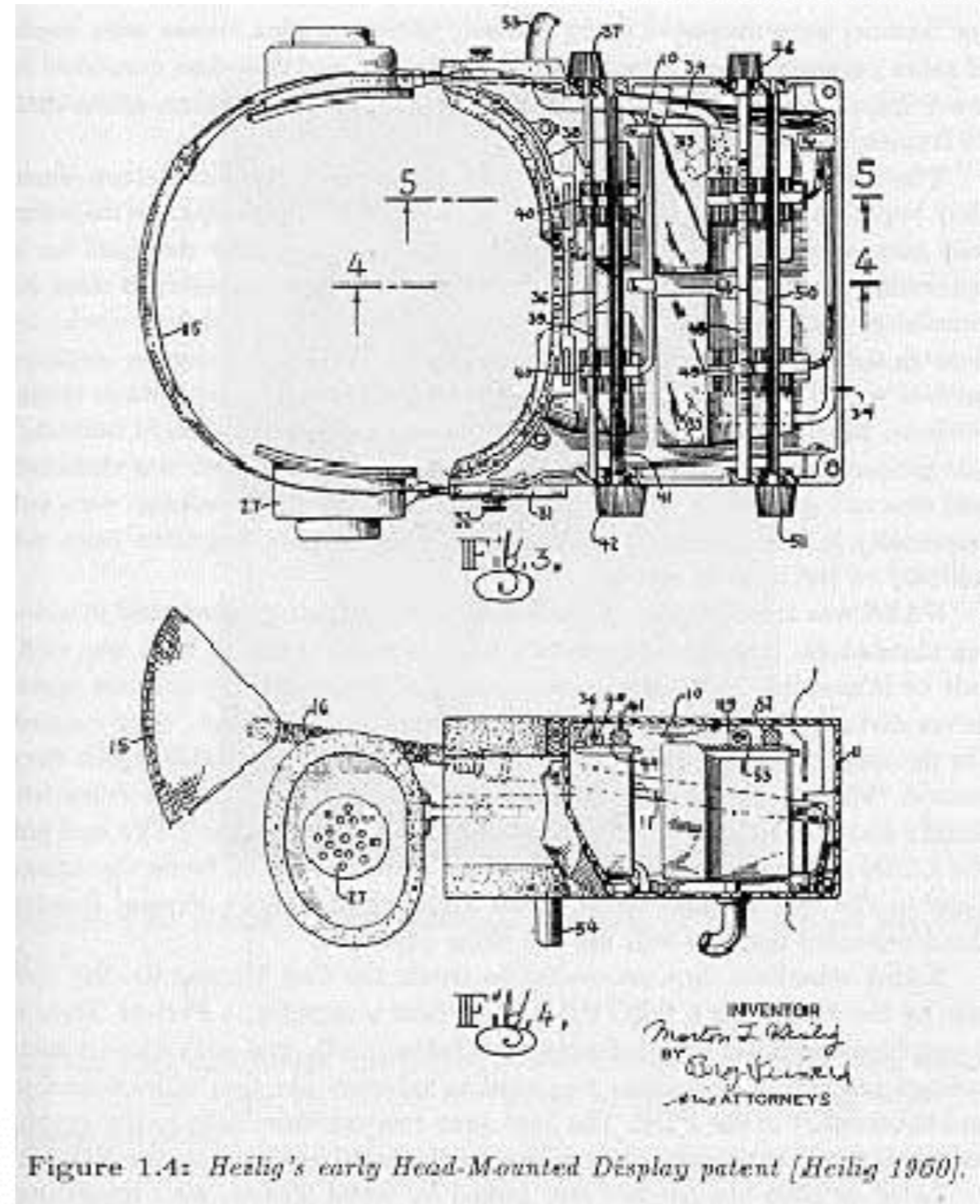
Ubiquitous Computing



- Computing and sensing embedded in real world
- Particle devices, RFID, motes, arduino, etc.

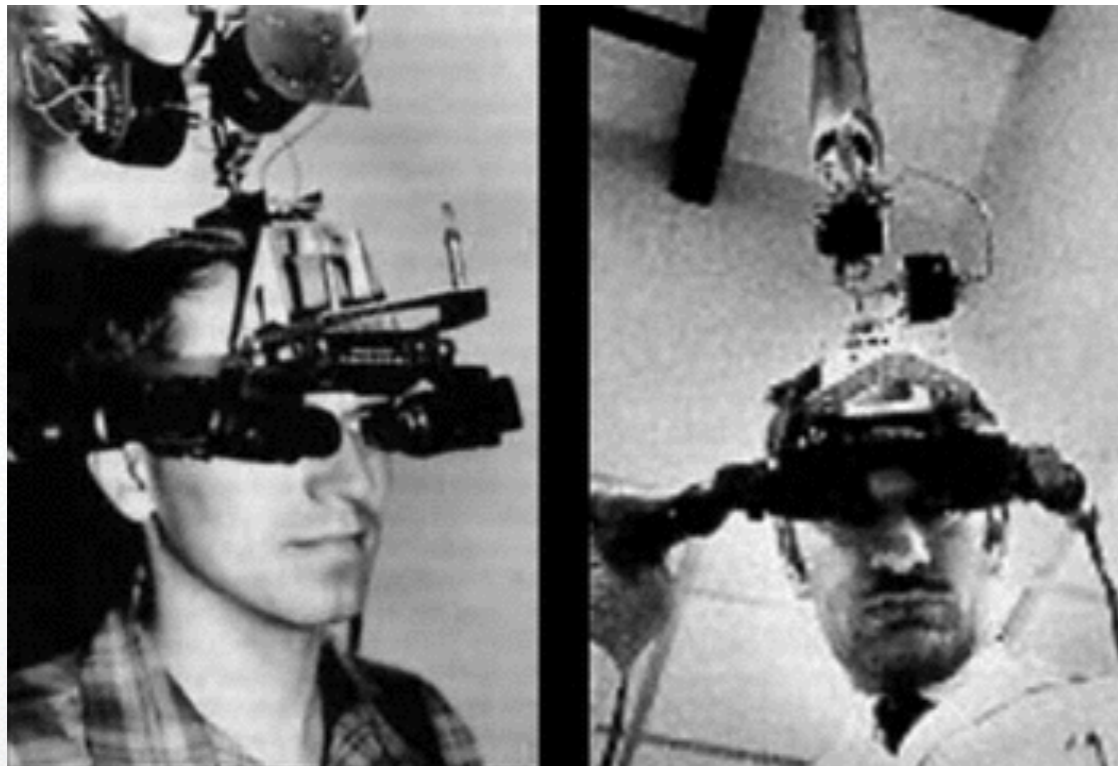
Virtual Reality

- Morton Heilig
 - Not in computers!
 - Surround sound idea for the eyes...
- Why use 18% of the viewer's FOV in 2D, when we can use 100% in 3D...

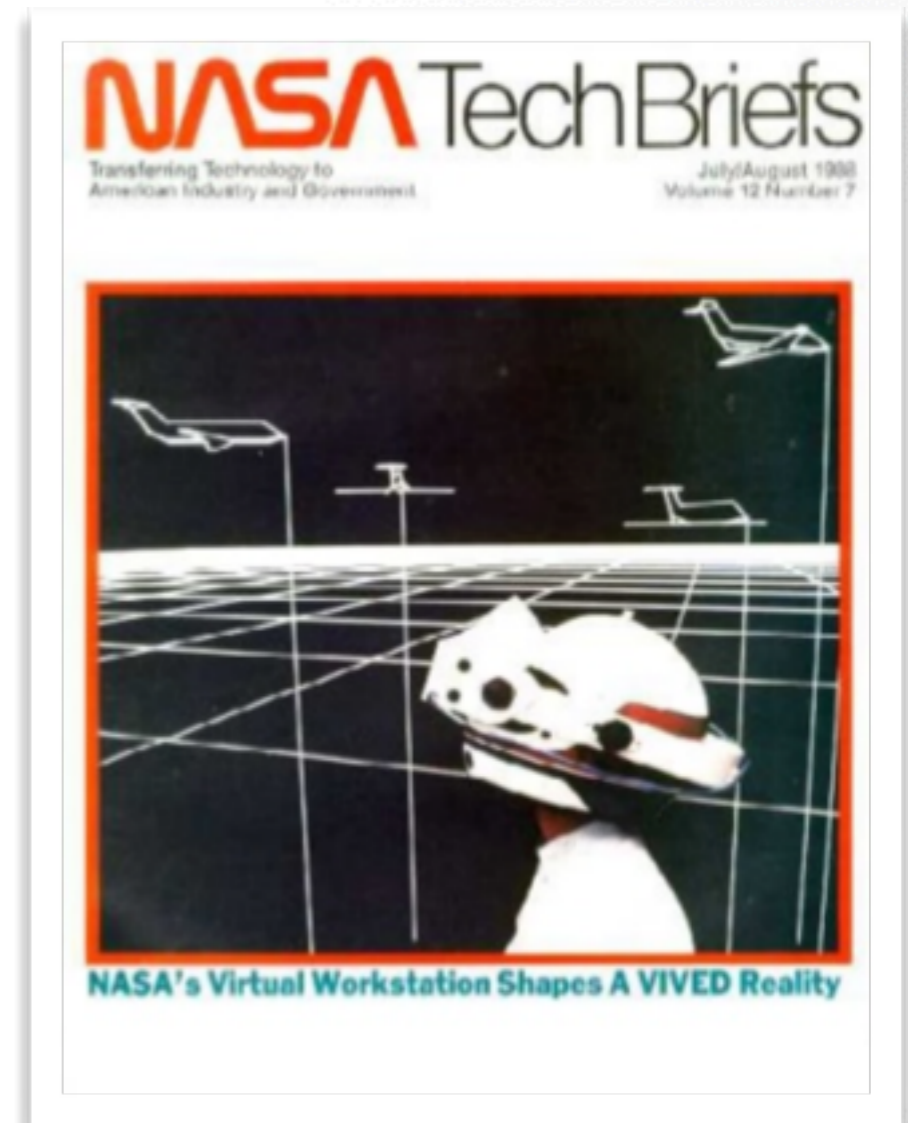


Virtual Reality

- Too expensive, Heilig's plans fell through
- Sensorama! (early 60s)
- Ivan Sutherland continued (CRT's, CGI), flight sims

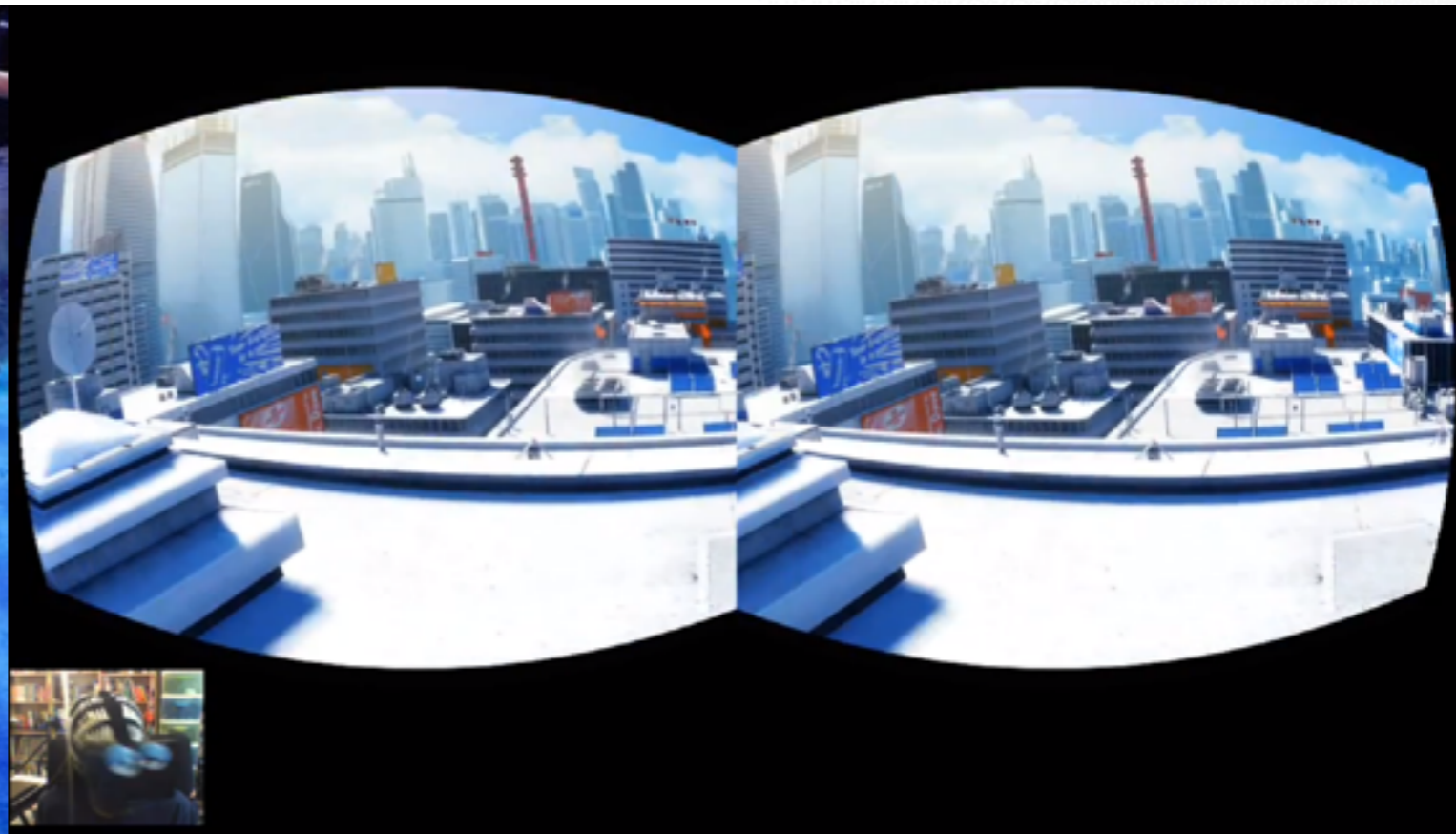


Virtual Reality



- 1985...

Virtual Reality



Immersive VR

- Head mounted display, gloves
- Separation from the real world

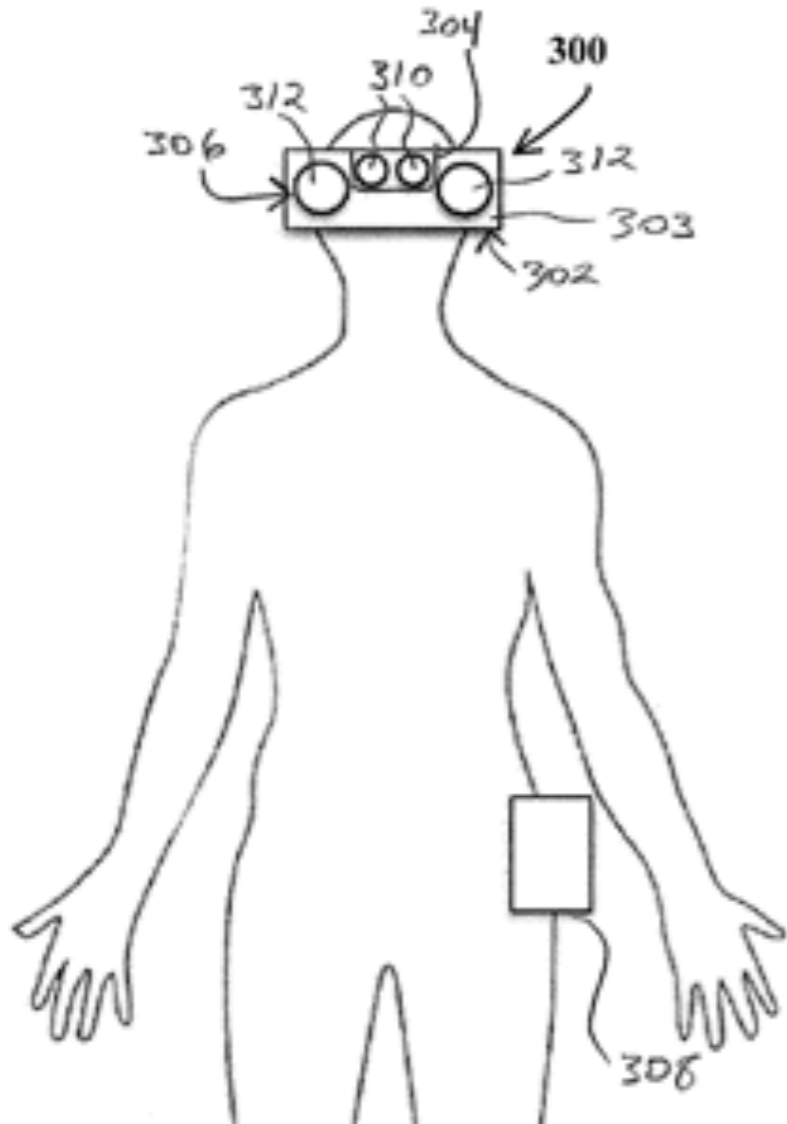
Augmented Reality

Defining Characteristics [Azuma 97]

- Combines Real and Virtual Images
 - Both can be seen at the same time
- Interactive in real-time
 - The virtual content can be interacted with
- Registered in 3D
 - Virtual objects appear fixed in space

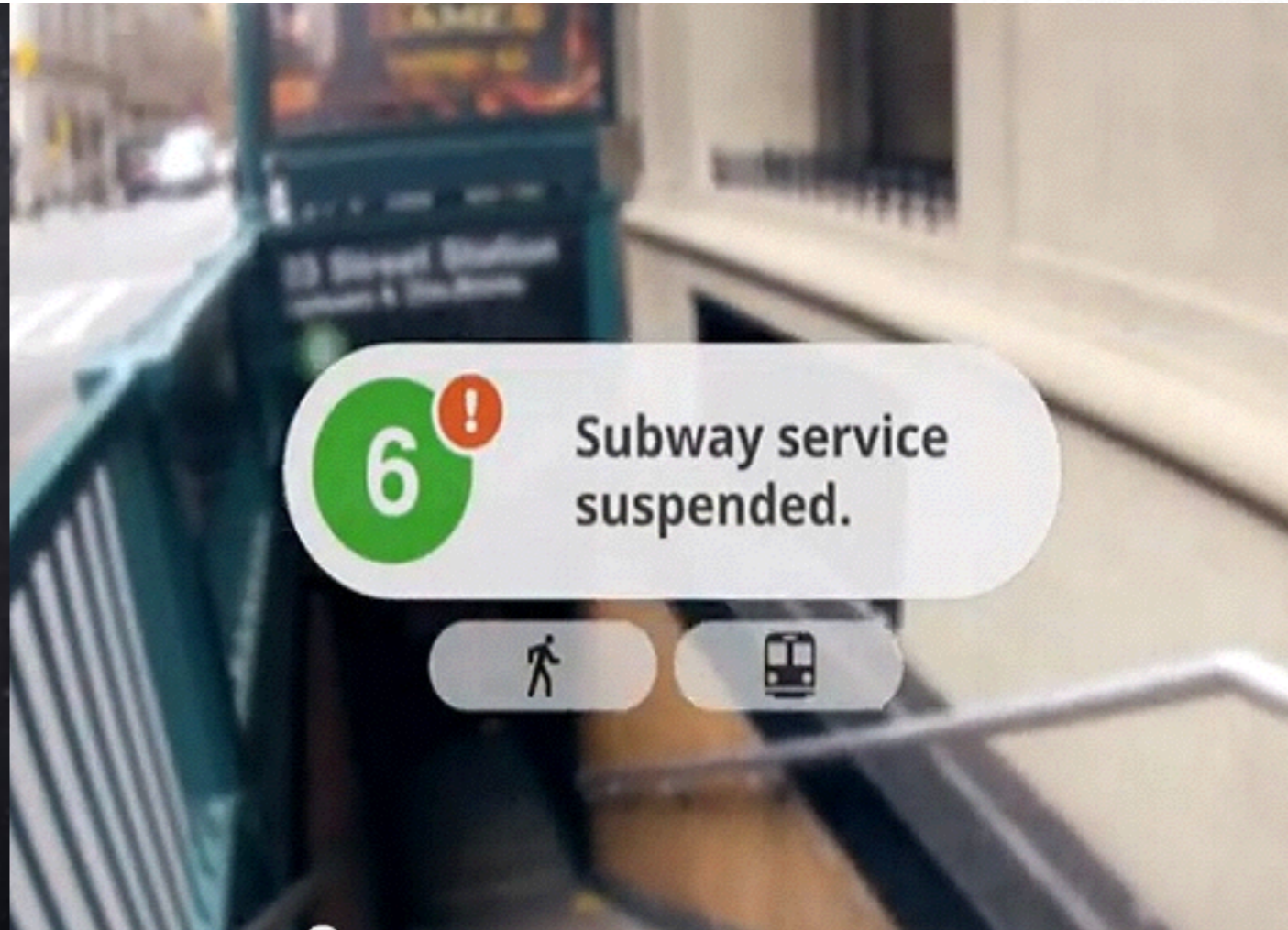
Azuma, R. T. (1997). A survey of augmented reality. *Presence*, 6(4), 355-385

Augmented Reality Examples



Magic Leap

Augmented Reality Examples



Google Glass

VR vs AR

Virtual Reality: Replaces Reality

- Scene Generation: requires realistic images
- Display Device: fully immersive, wide FOV
- Tracking and Sensing: low accuracy used to be okay

Augmented Reality: Enhances Reality

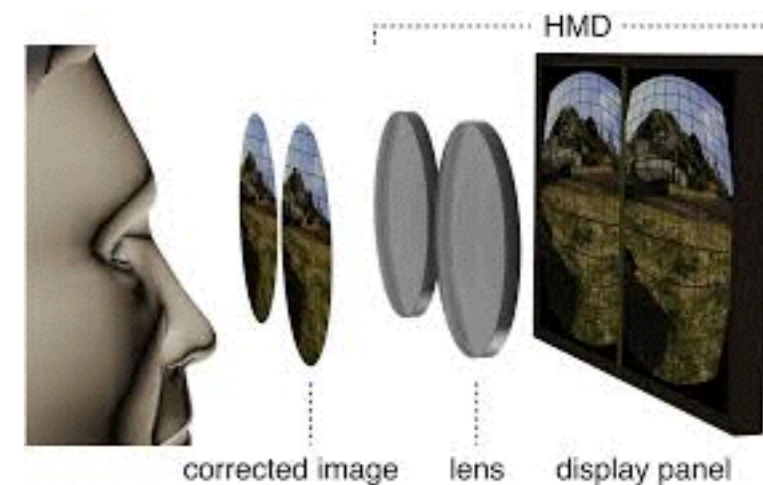
- Scene Generation: minimal rendering okay
- Display Device: non-immersive, small FOV
- Tracking and Sensing: high accuracy needed

Milgram's Reality-Virtuality Continuum



Recent Advances

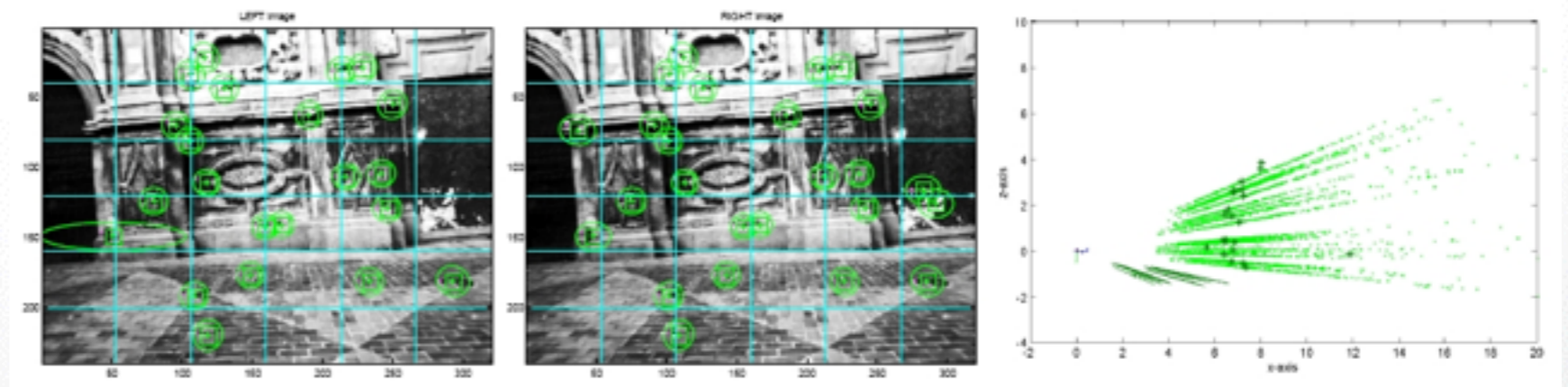
- Low cost production
 - Wide-FOV (>110) Single Display
 - Cheap lenses
- OLED-driven Low Persistency Displays
 - Less smearing and ghosting artefacts
 - Sliced time frame rendering
 - Darker games are an improvement
- High-quality realtime 3D content



Challenges: VR HMDs

Oculus Connect 2014, John Carmack:

- Higher framerates without flicker problems
 - DK2 achieves 75Hz, optimal is 90-120 Hz
 - Resolution vs framerate vs bandwidth
- Inaccurate positional tracking
 - Submillimeter tracking - SLAM +IMU(Accelerometers/Magnetometers)
 - Relative velocity vs relative position?
 - No Jittering



Challenges: Digital Content



Damocles ...

<http://cs420.hao-li.com>

Thanks!

