Fall 2018

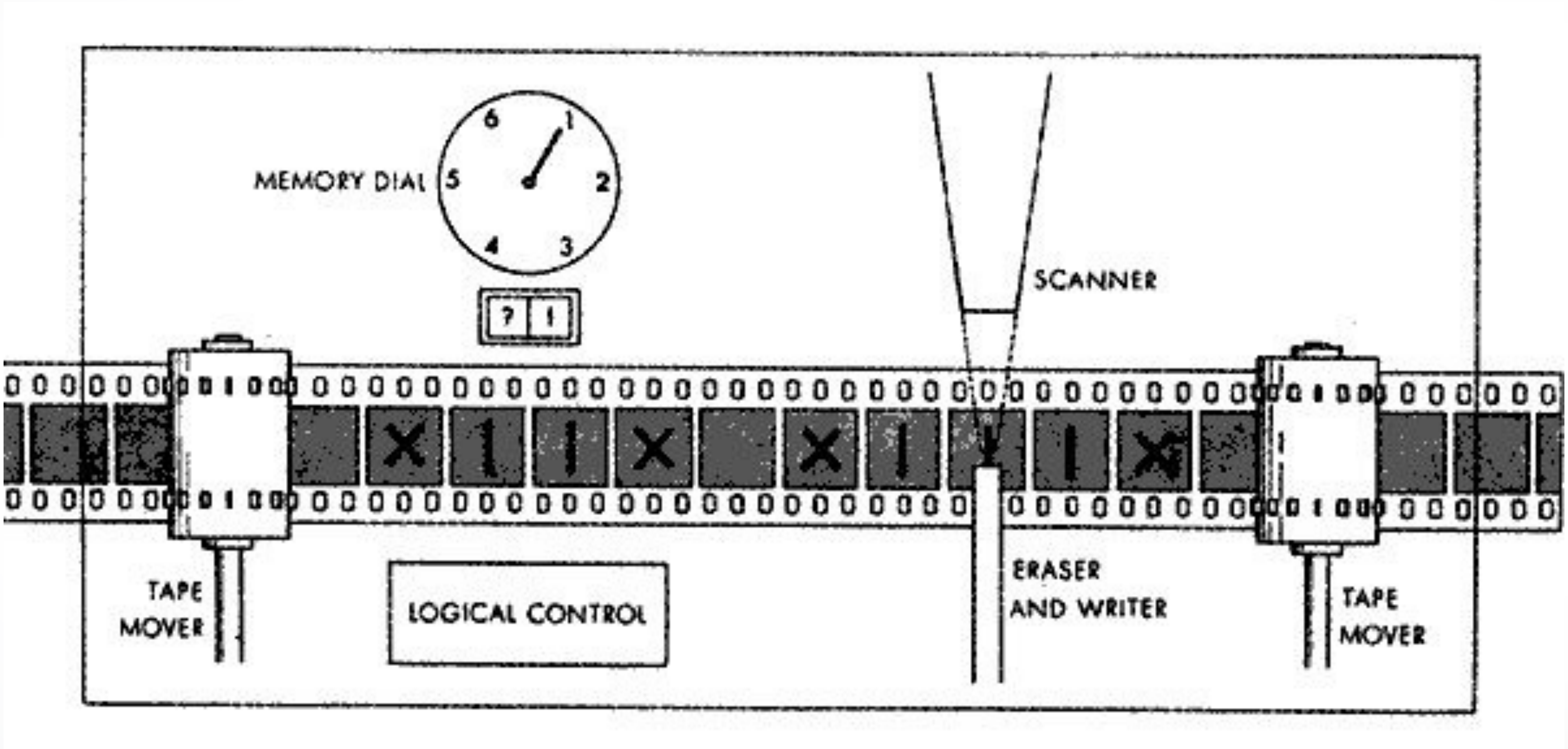
CSCI 420: **Computer Graphics**

14.1 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**

ACM **SIGGRAPH**

SIGGRAPH

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

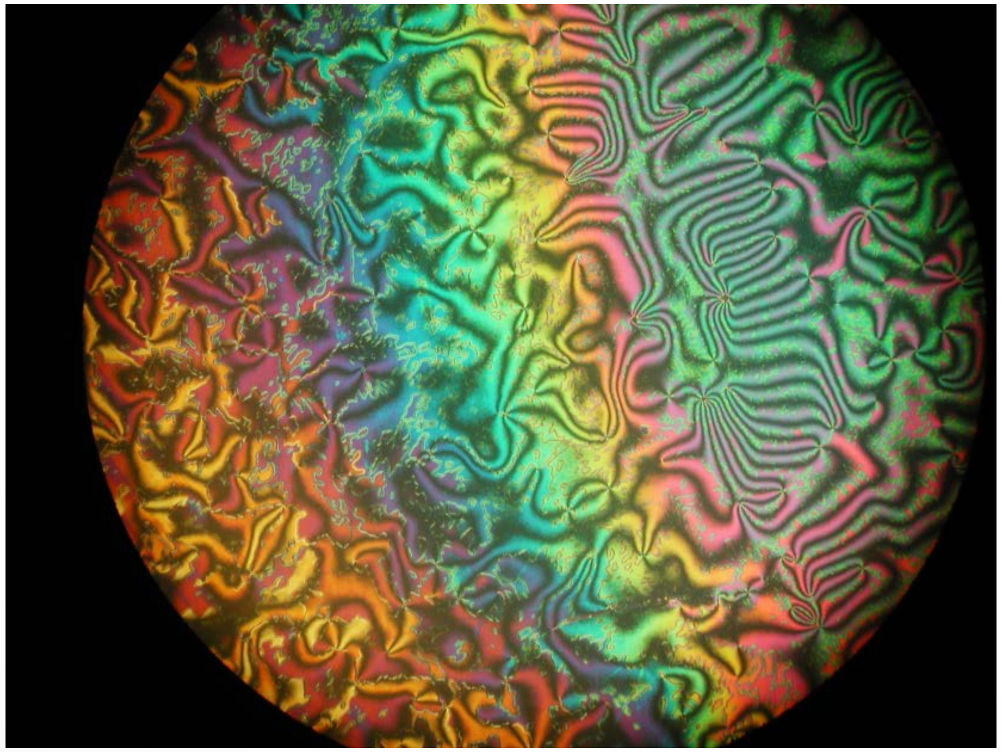
Display Technologies

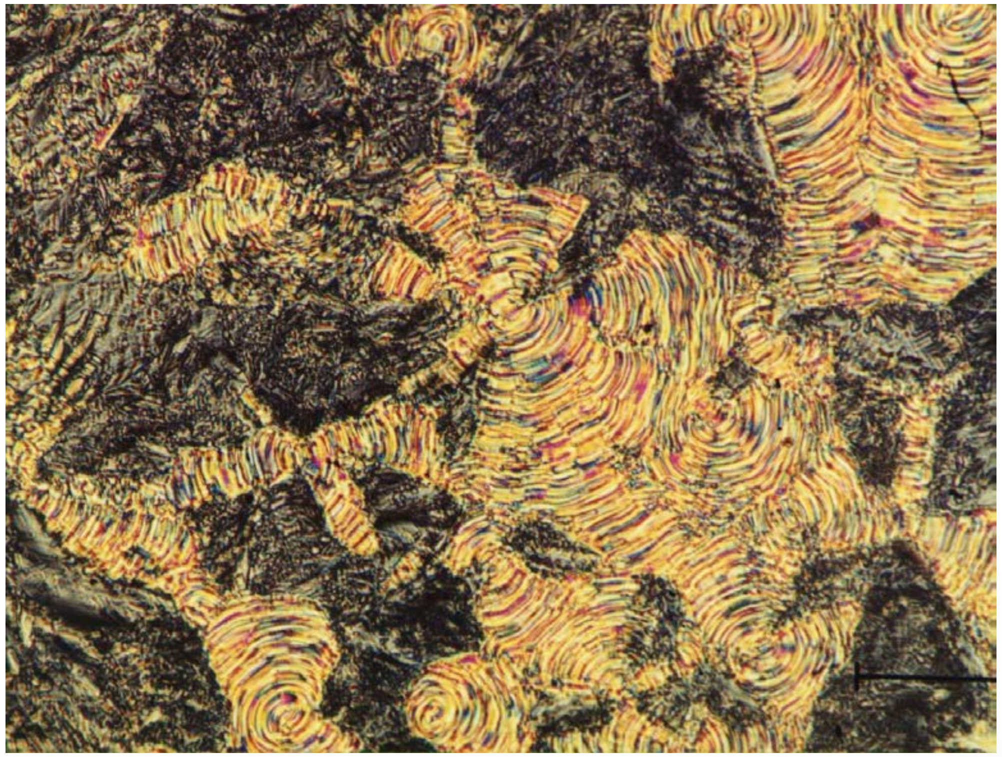
- **Liquid Crystal Display**

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

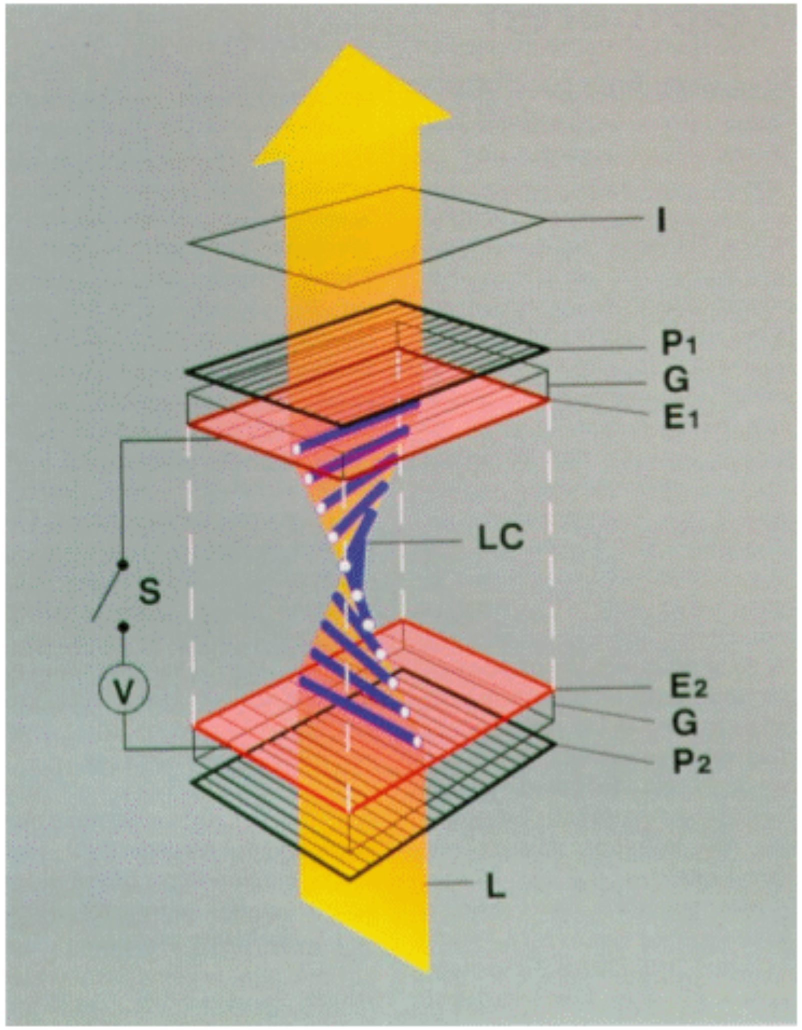


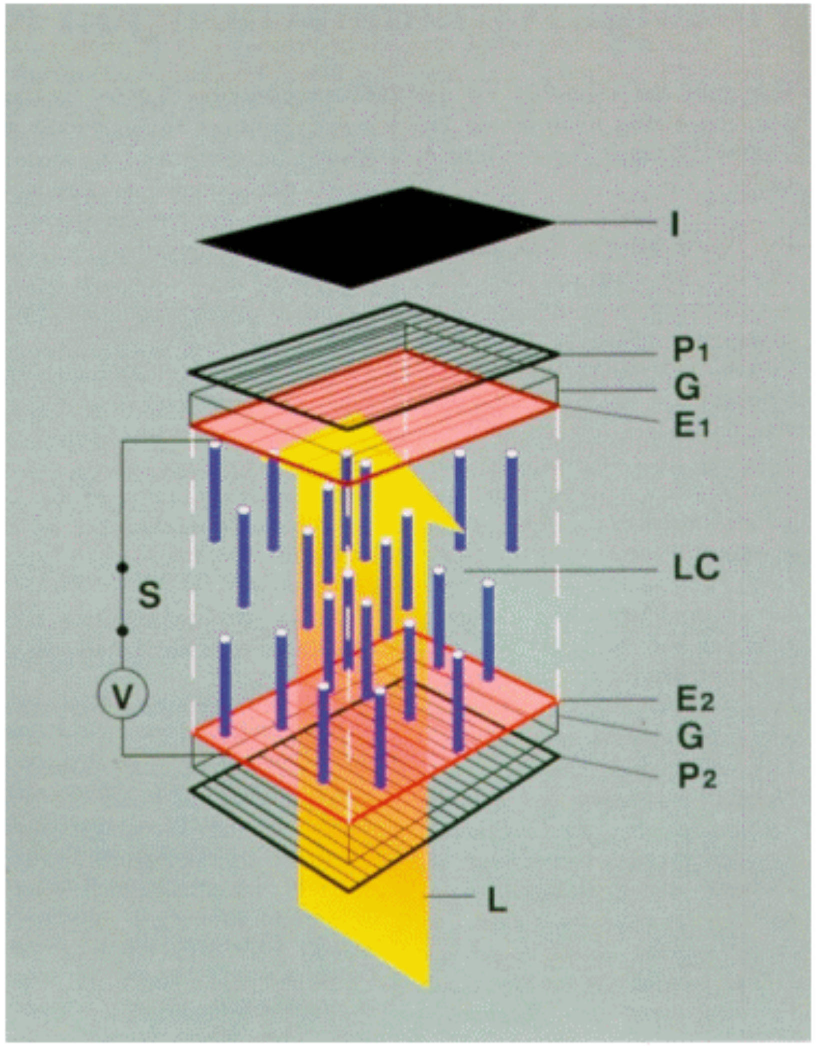


Anisotropic pattern depending on electricity, heat, etc.

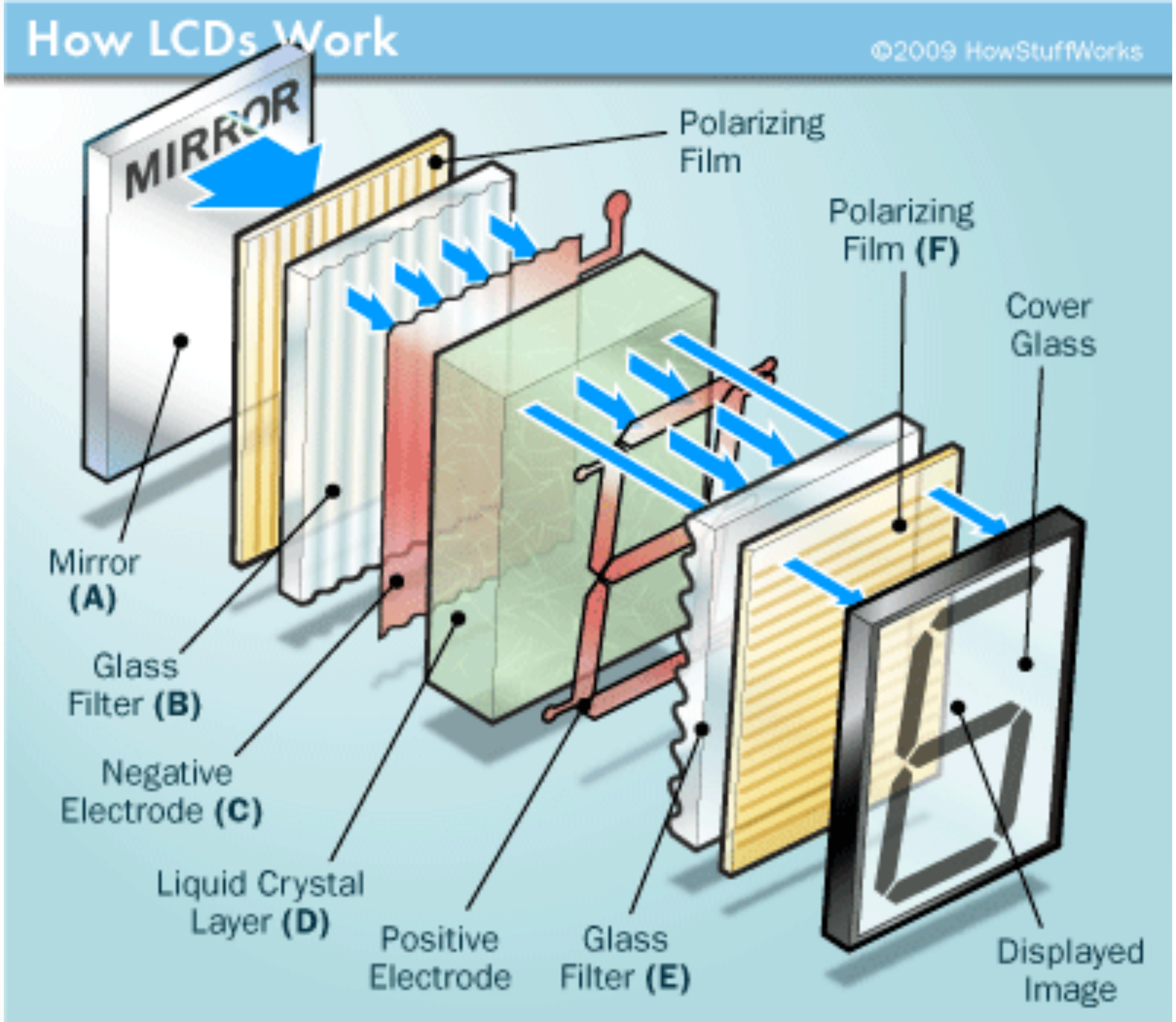
Liquid Crystals

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





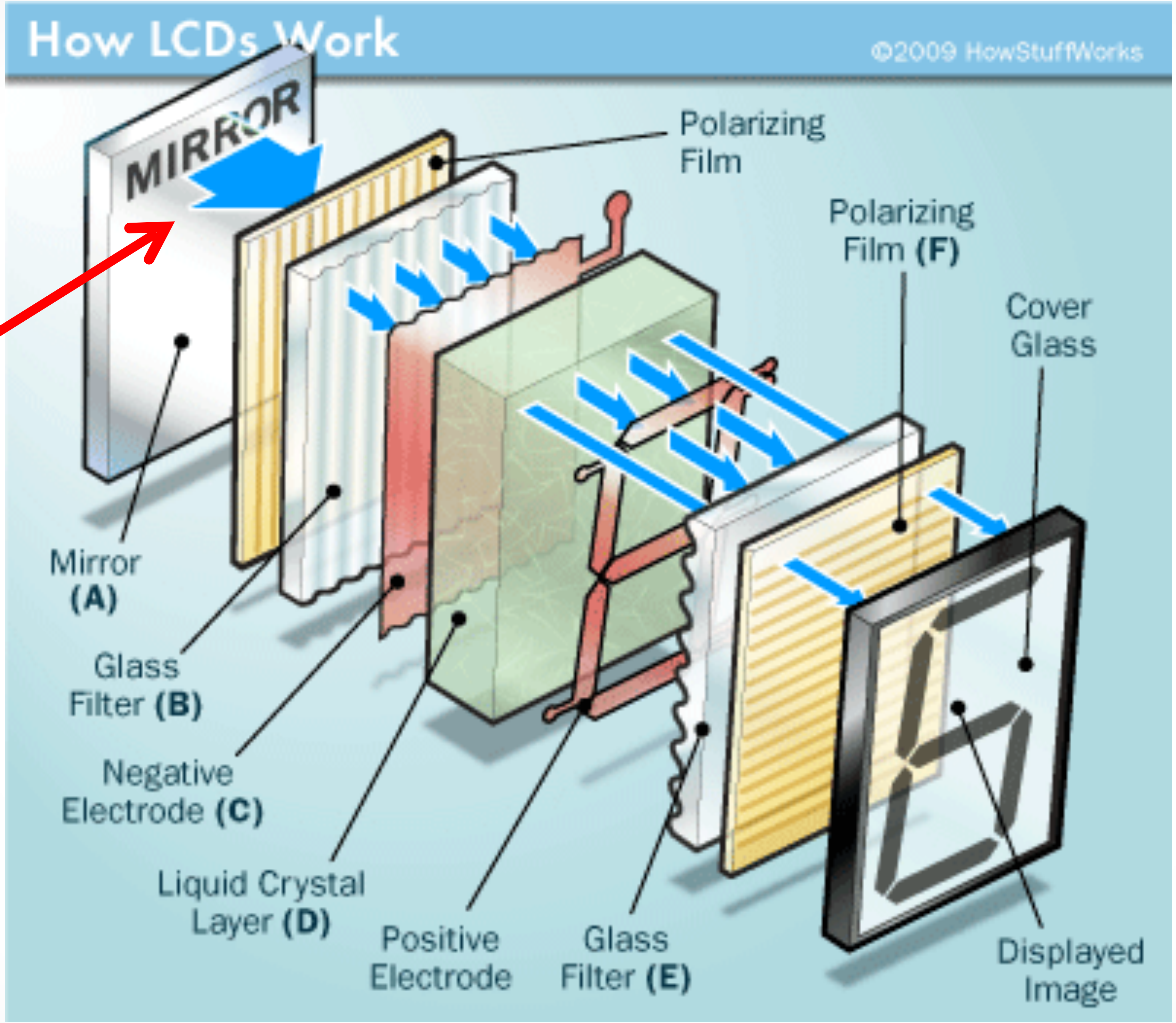
LCD Light Path



http://electronics.howstuffworks.com/lcd2.htm

LCD Light Path

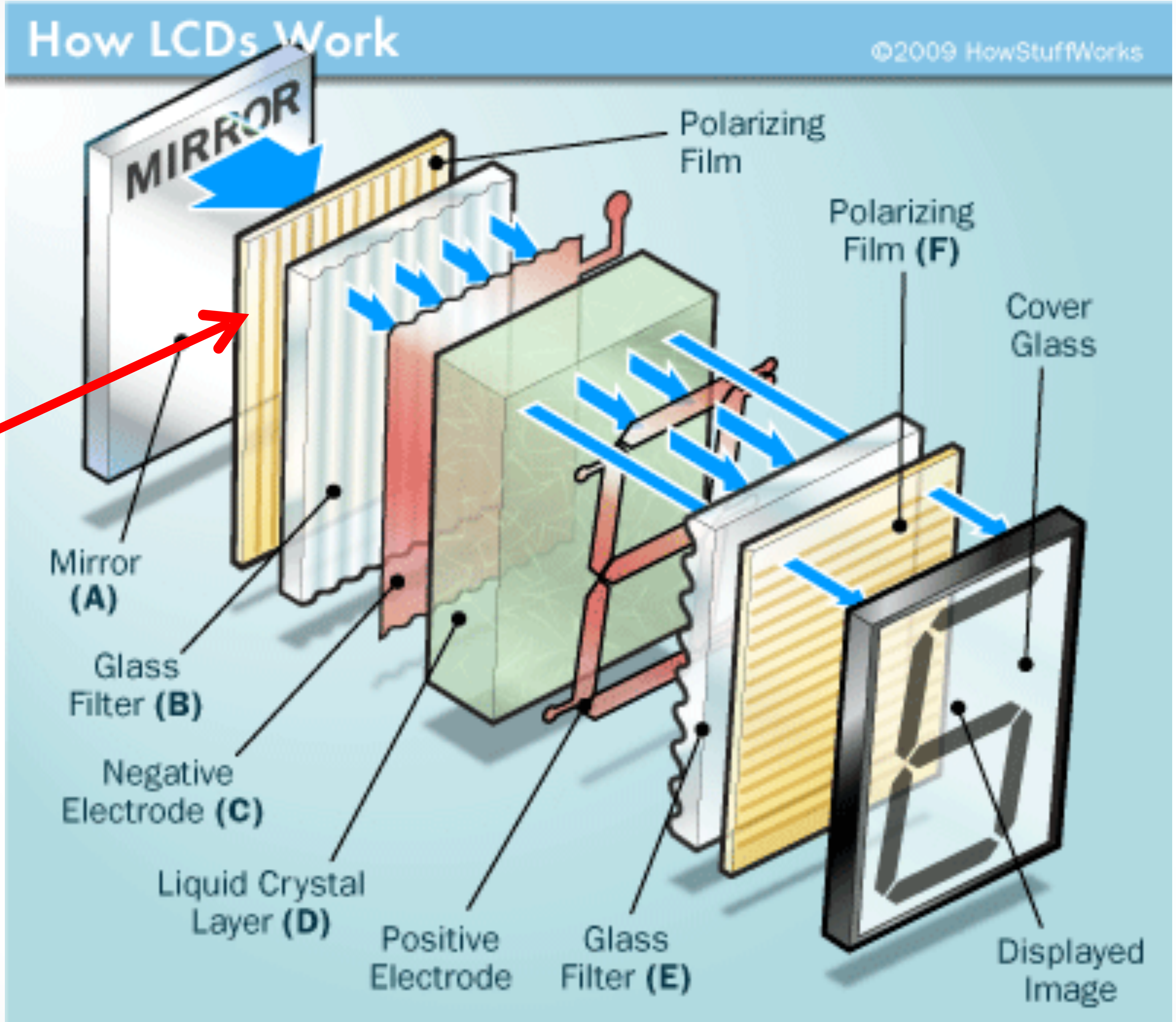
Light Source



http://electronics.howstuffworks.com/lcd2.htm

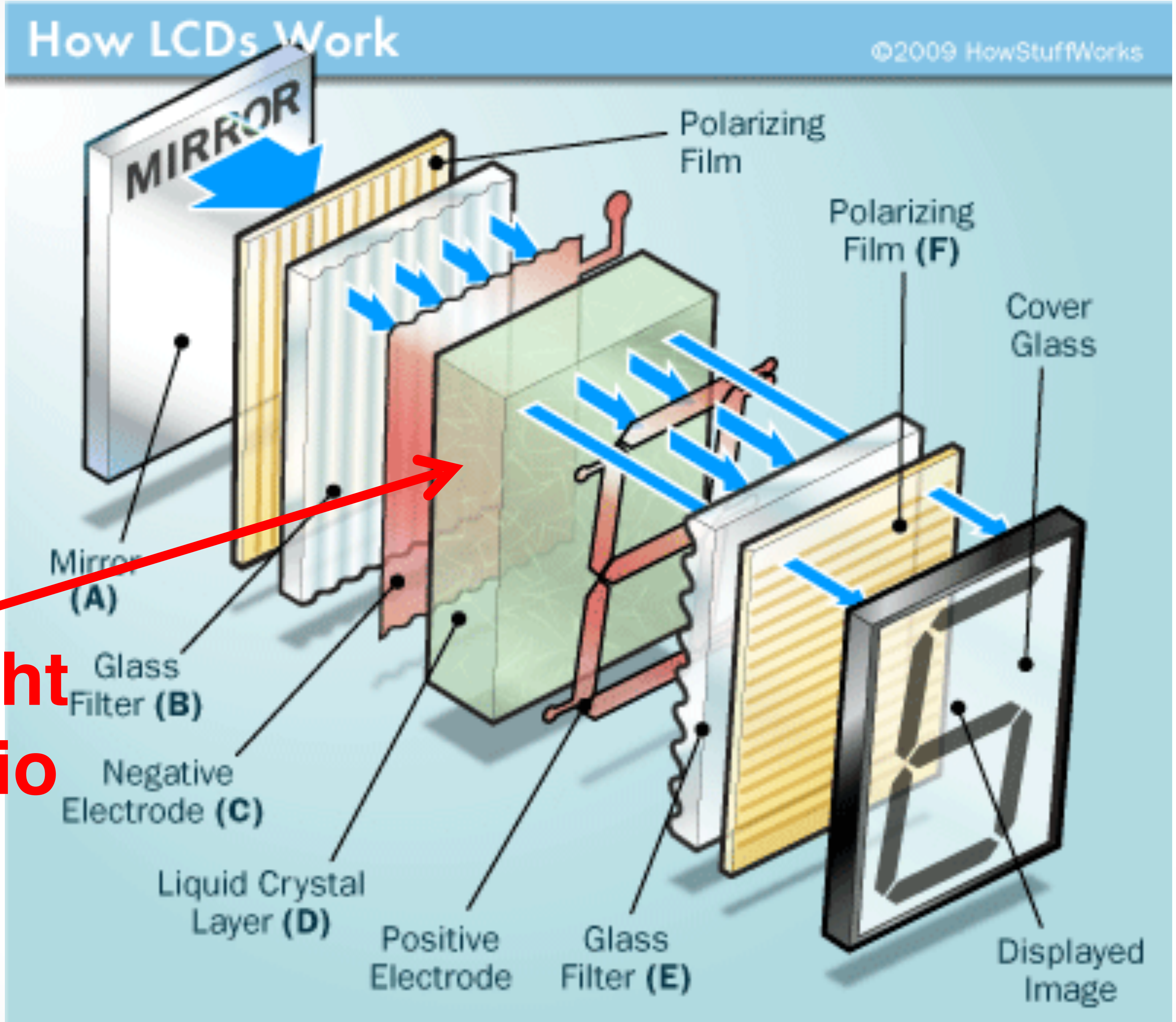
LCD Light Path

Polariz
e



http://electronics.howstuffworks.com/lcd2.htm

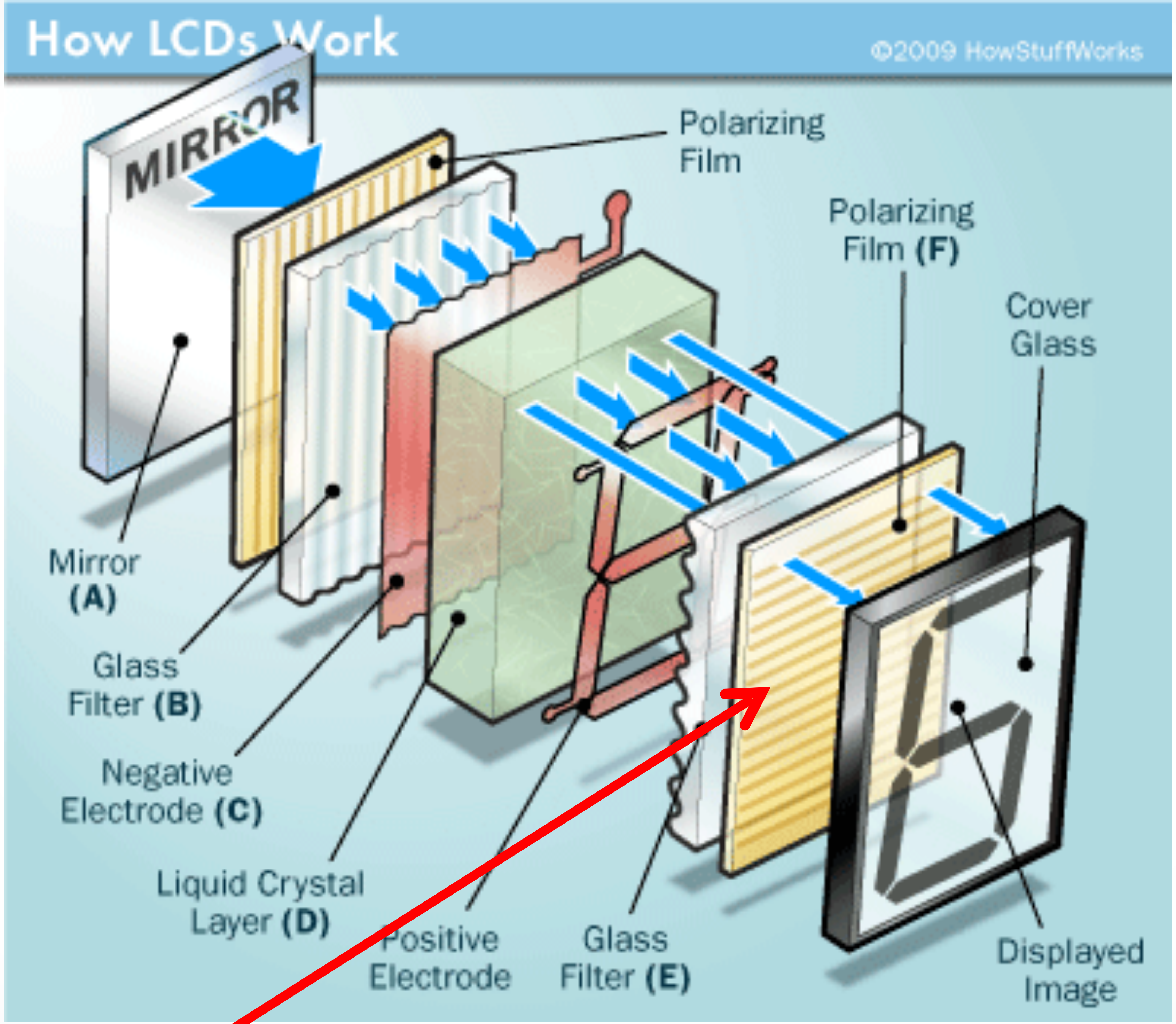
LCD Light Path



Twist Light Polarization

http://electronics.howstuffworks.com/lcd2.htm

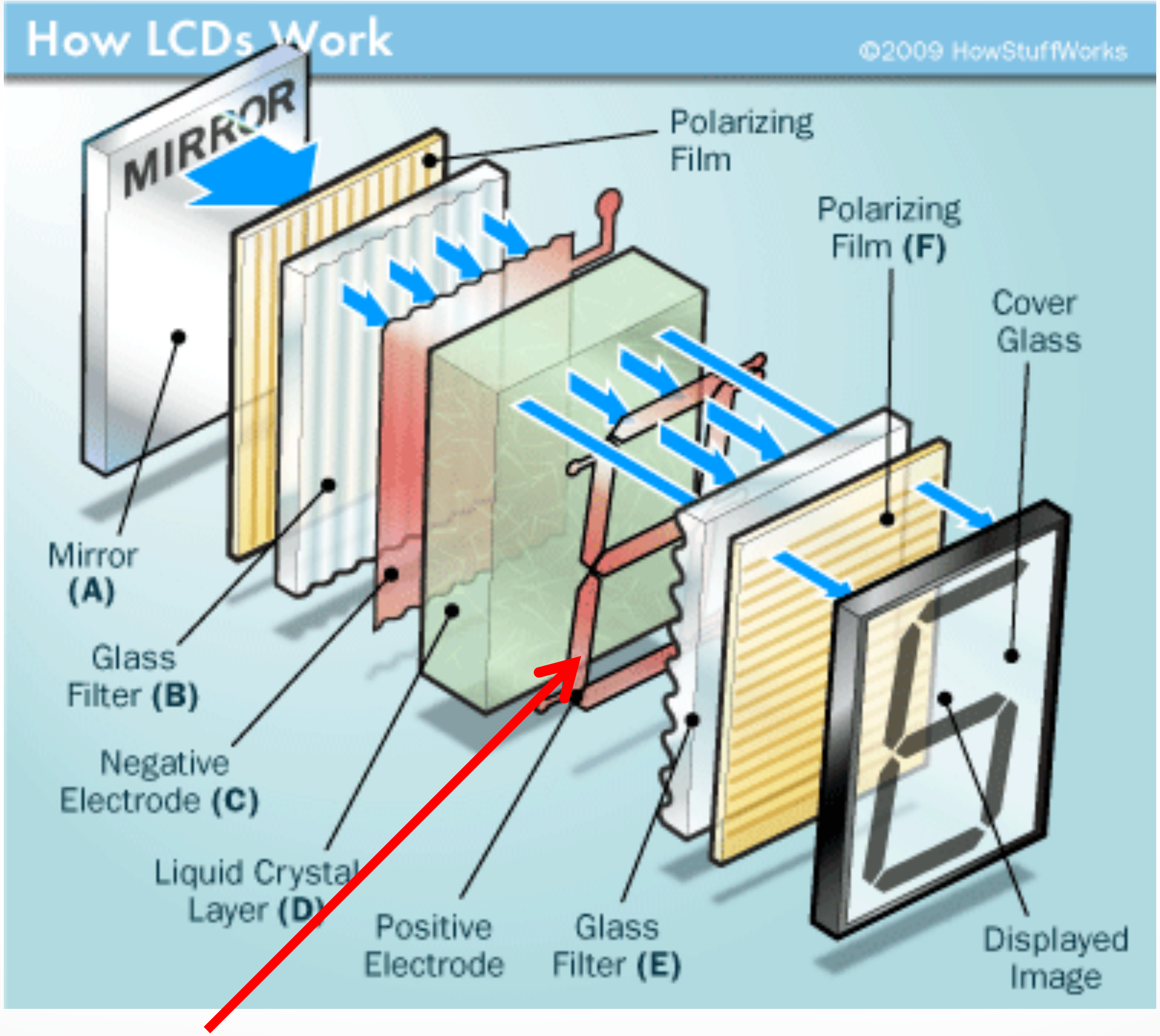
LCD Light Path



Only twisted light makes it through

http://electronics.howstuffworks.com/lcd2.htm

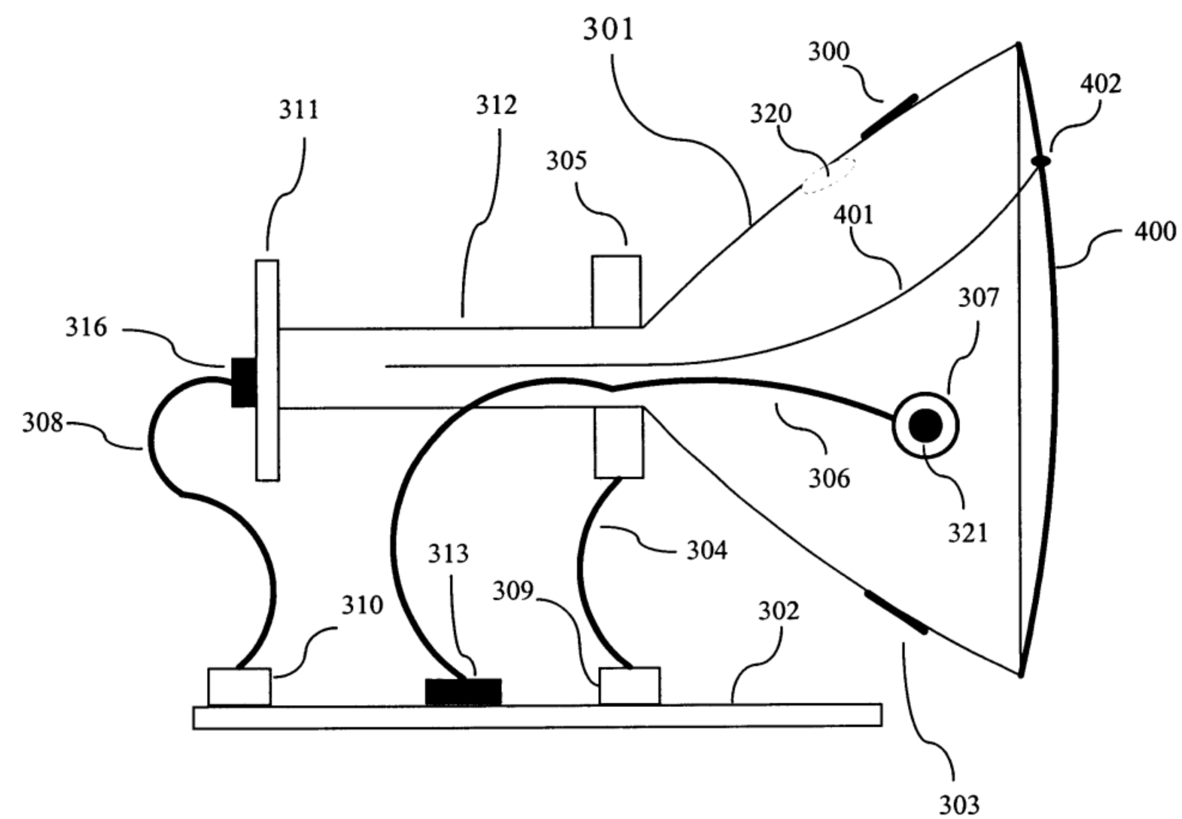
LCD Light Path



Electrode controls crystals

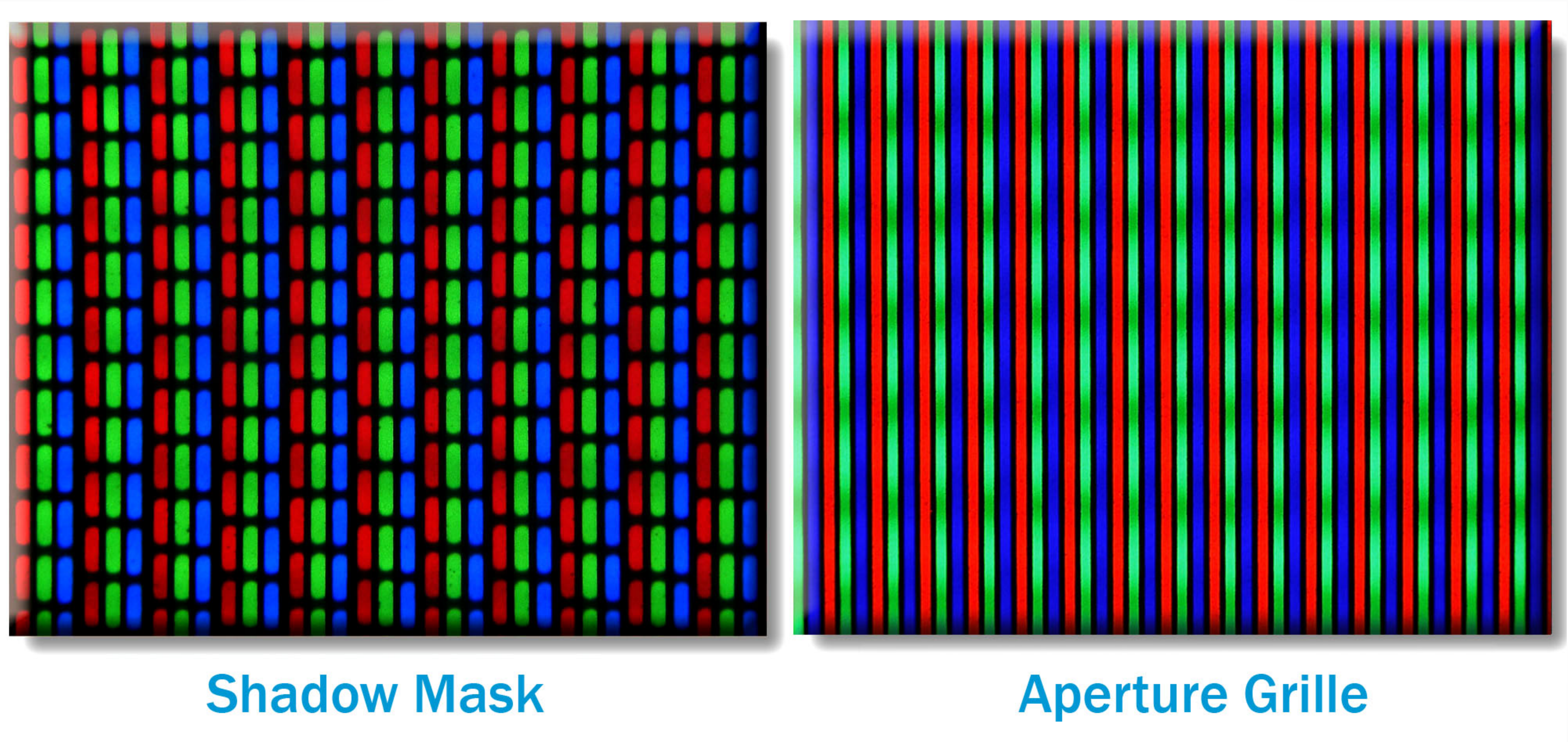
http://electronics.howstuffworks.com/lcd2.htm

Cathode Ray Tube (CRT)



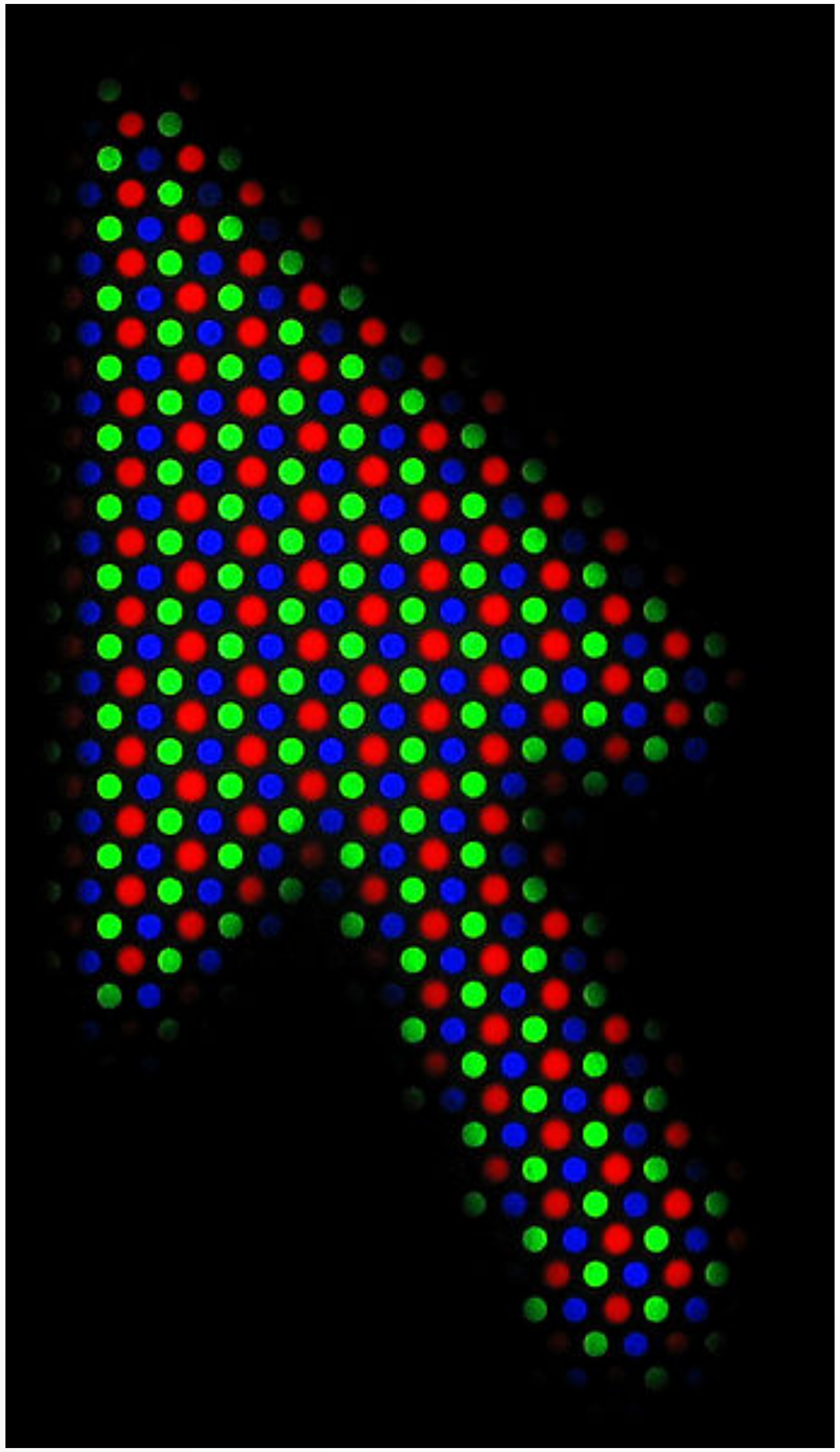
http://img.diytrade.com/cdimg/597243/7515356/0/1276139831/Sell_CRT_Monitor.jpg
http://www.freepatentsonline.com/6741296-0-large.jpg

Practical Display Issues



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

Practical Display Issues

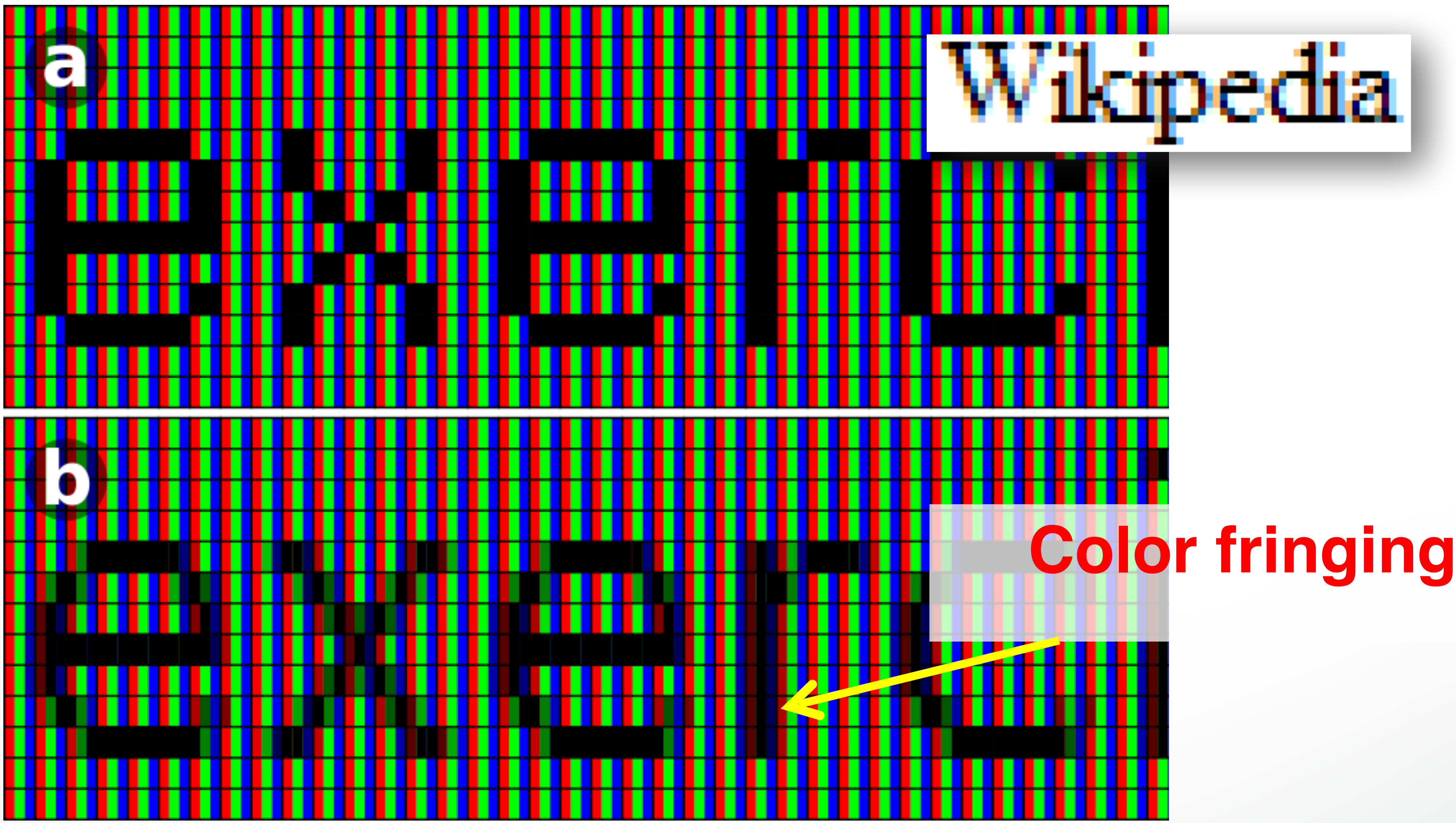


http://en.wikipedia.org/wiki/File:Shadow_mask_closeup_cursor.jpg

Have to convert from RGB to display pattern

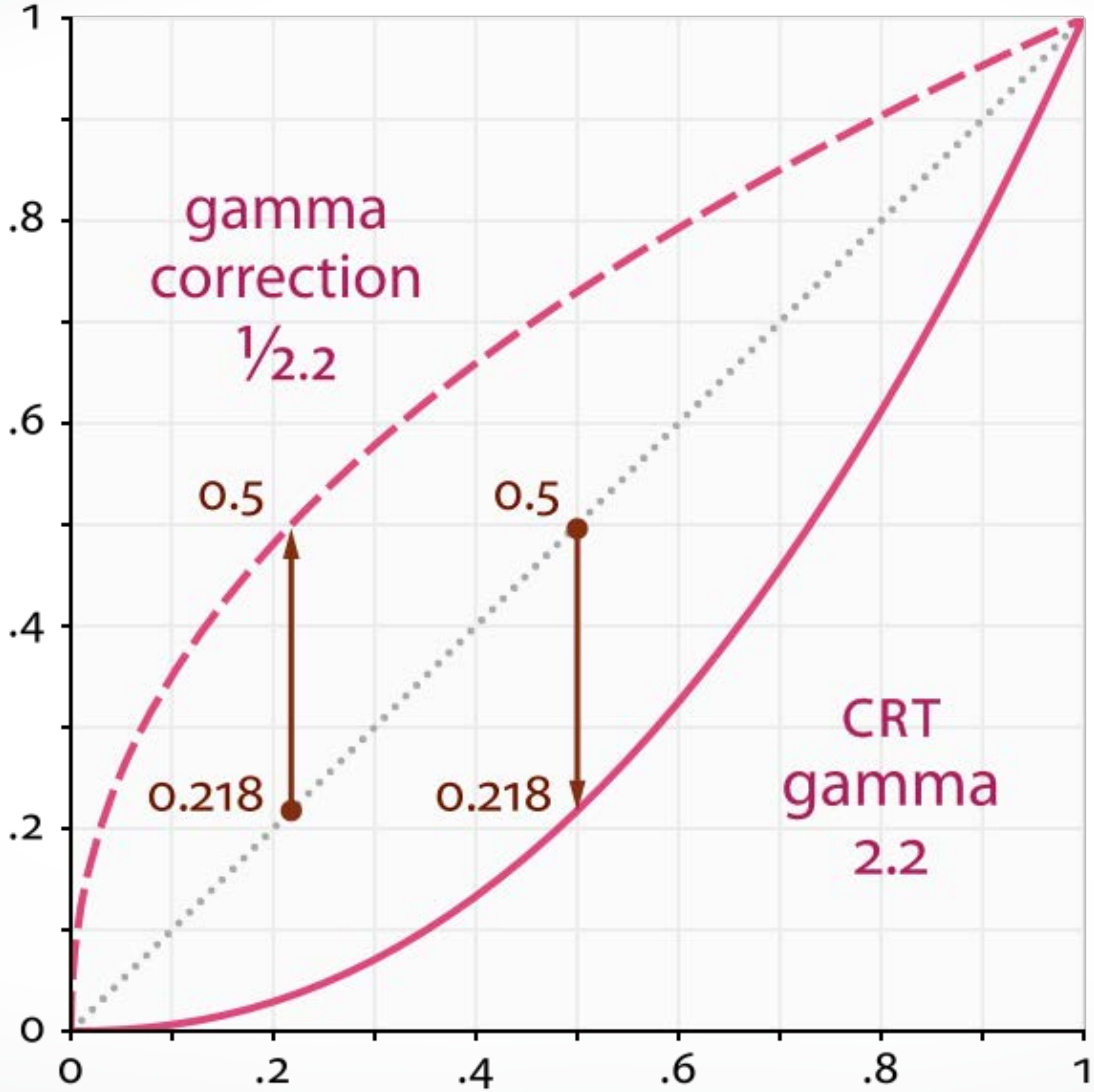
Subpixel Antialiasing

- Clear Type (Microsoft, 1998), subpixel rendering



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

Practical Display Issues



Practical Display Issues

Nonlinear relationship between brightness and intensity

Perceptual ↑ (brightness)

Display-related ↑ (intensity)

Practical Display Issues

Nonlinear relationship between brightness and intensity

Nonlinear relationship between intensity and hardware response

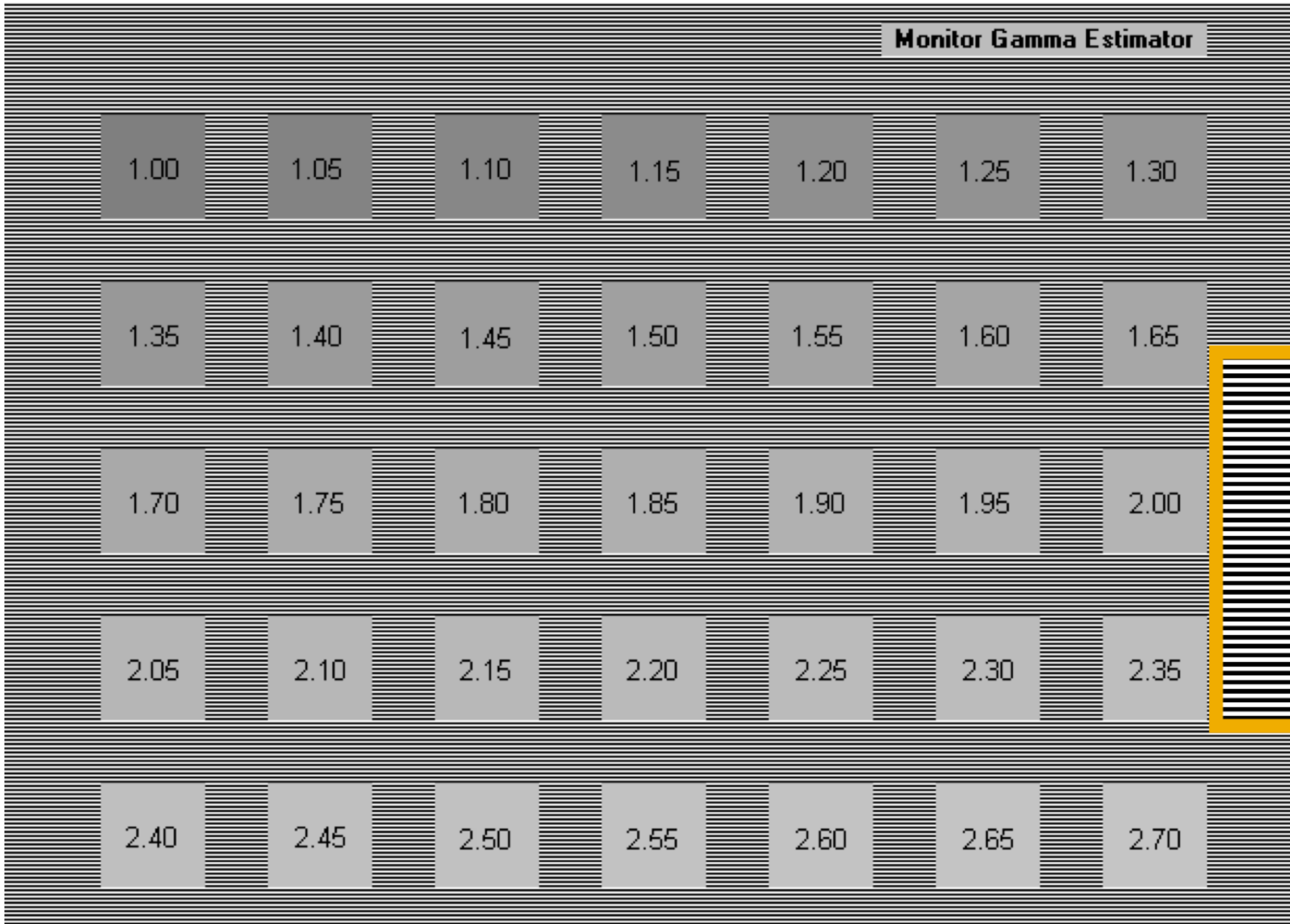
Gamma Model: For Displays

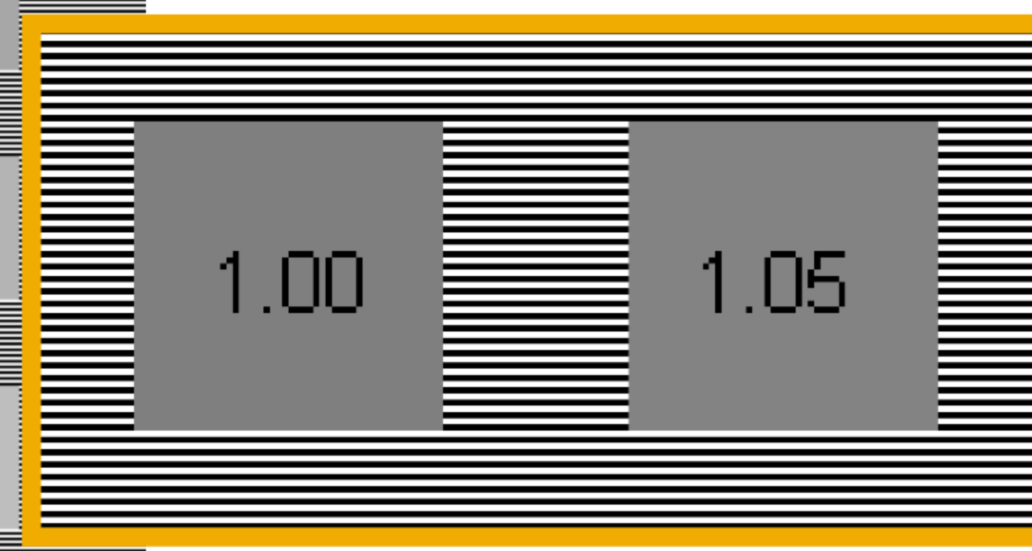
$$\text{displayed intensity} = (\text{maximum intensity})a^{\gamma}$$

Pixel color

Gamma Model: For Displays

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





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

Gamma Model: For Displays

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

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

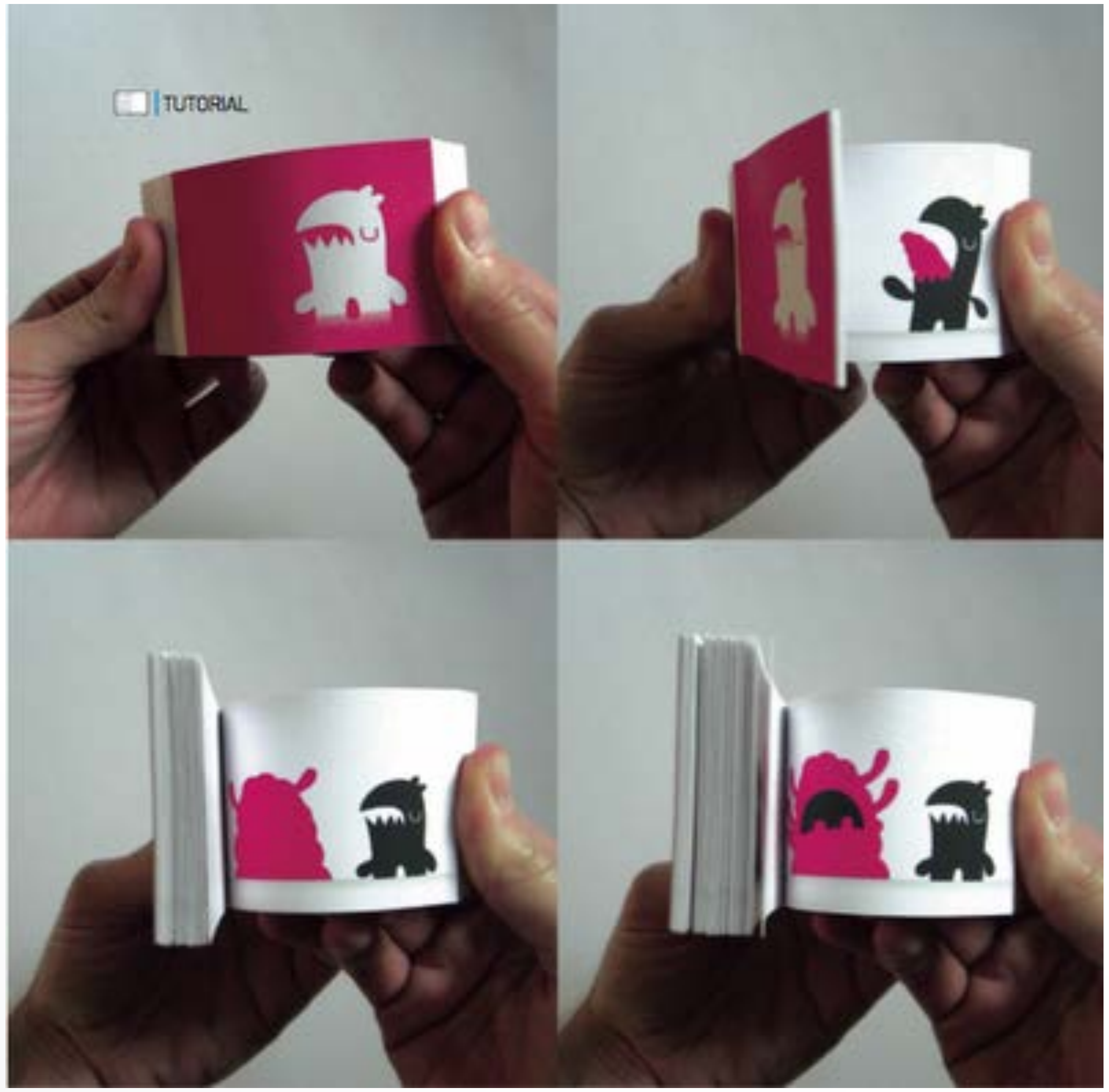
Why don't we do this always?

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**.

http://darlingdarleen.blogspot.com/2008_01_01_archive.html

Other Displays

LCD Shutter

Alternate between eyes

Digital Light Processing (DLP)

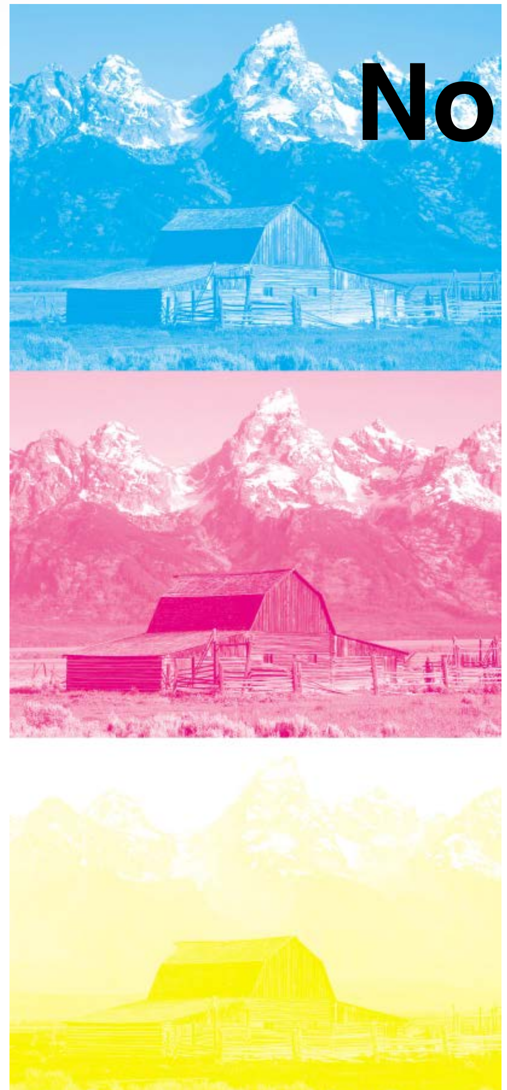
Spinning color wheel

http://graphics.stanford.edu/courses/cs148-11-fall/lectures/displays.pdf

Other Displays

Four primaries!

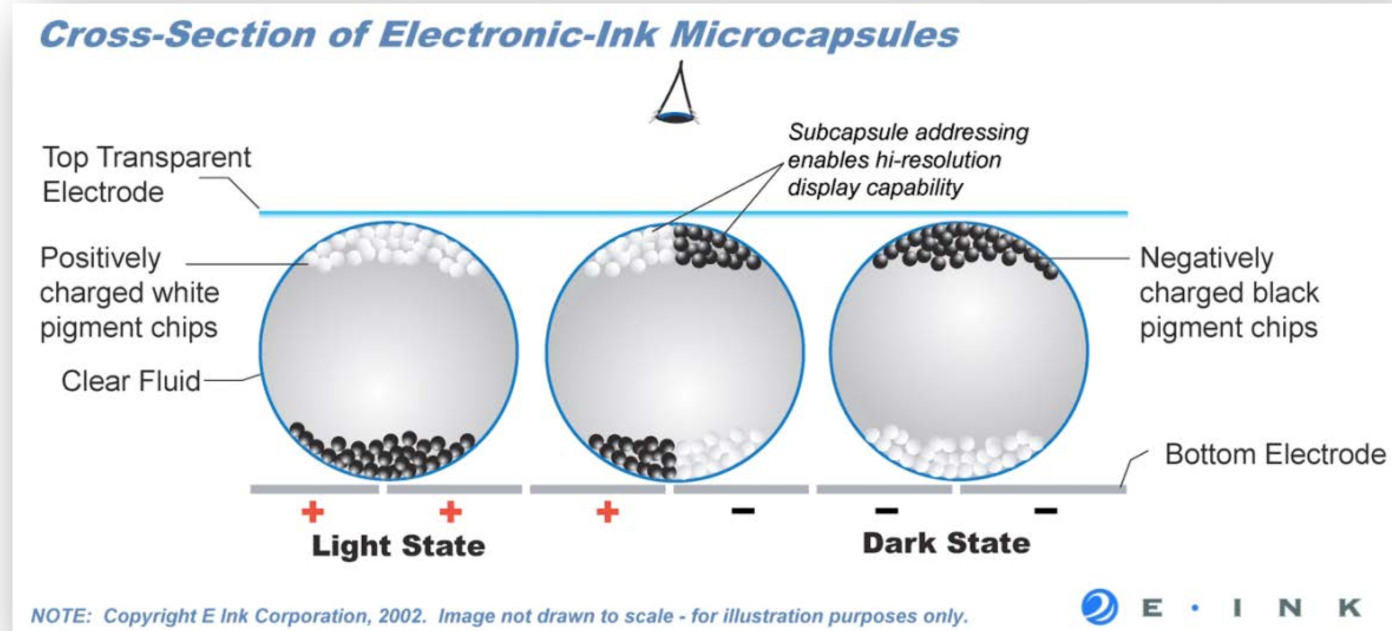
No black



Max black

http://en.wikipedia.org/wiki/CMYK_color_ model

Other Displays



Electronic ink

Different appearance, slow update rate

http://graphics.stanford.edu/courses/cs148-11-fall/lectures/displays.pdf

Dealing with Input

- **Events**

  Notify when state changes

- **Polling**

  Check for changed state

http://graphics.stanford.edu/courses/cs148-11-fall/lectures/interaction.pdf

Events

+

Efficient

-

Need to track state
Need to decide on events of interest

http://graphics.stanford.edu/courses/cs148-11-fall/lectures/interaction.pdf

Polling

+

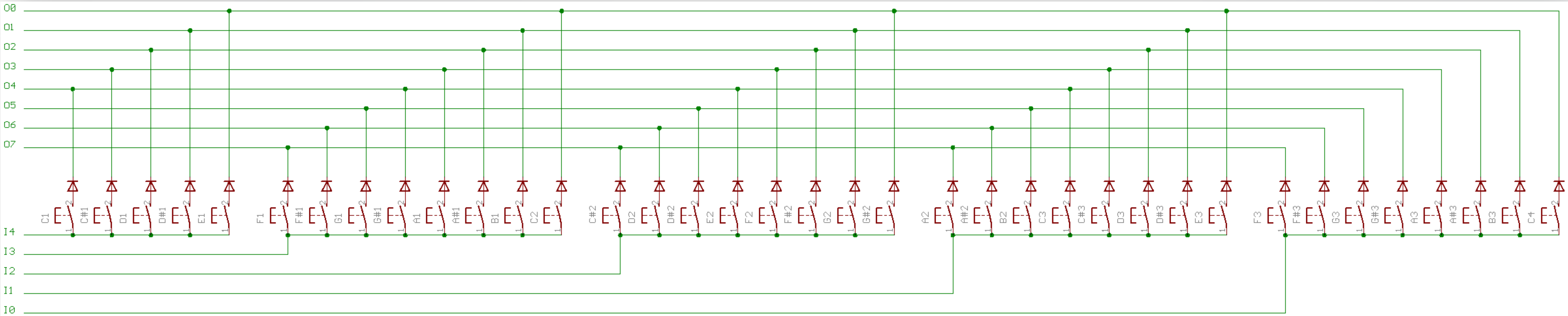
Cleanly deals with continuous state change

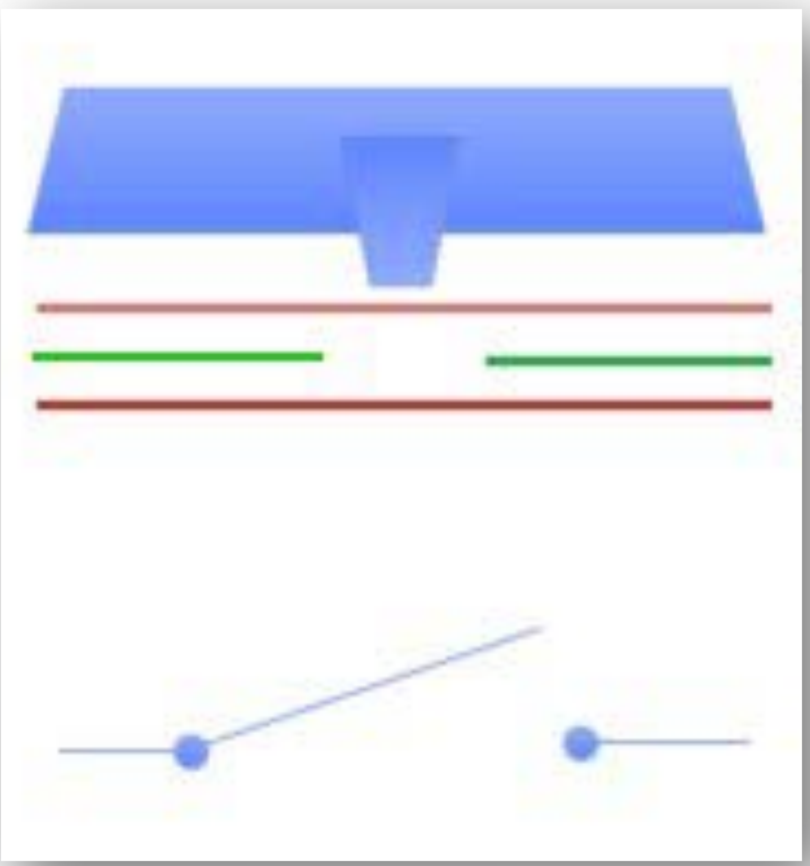
-

Could miss a state change
Considerable overhead

http://graphics.stanford.edu/courses/cs148-11-fall/lectures/interaction.pdf

Keyboards

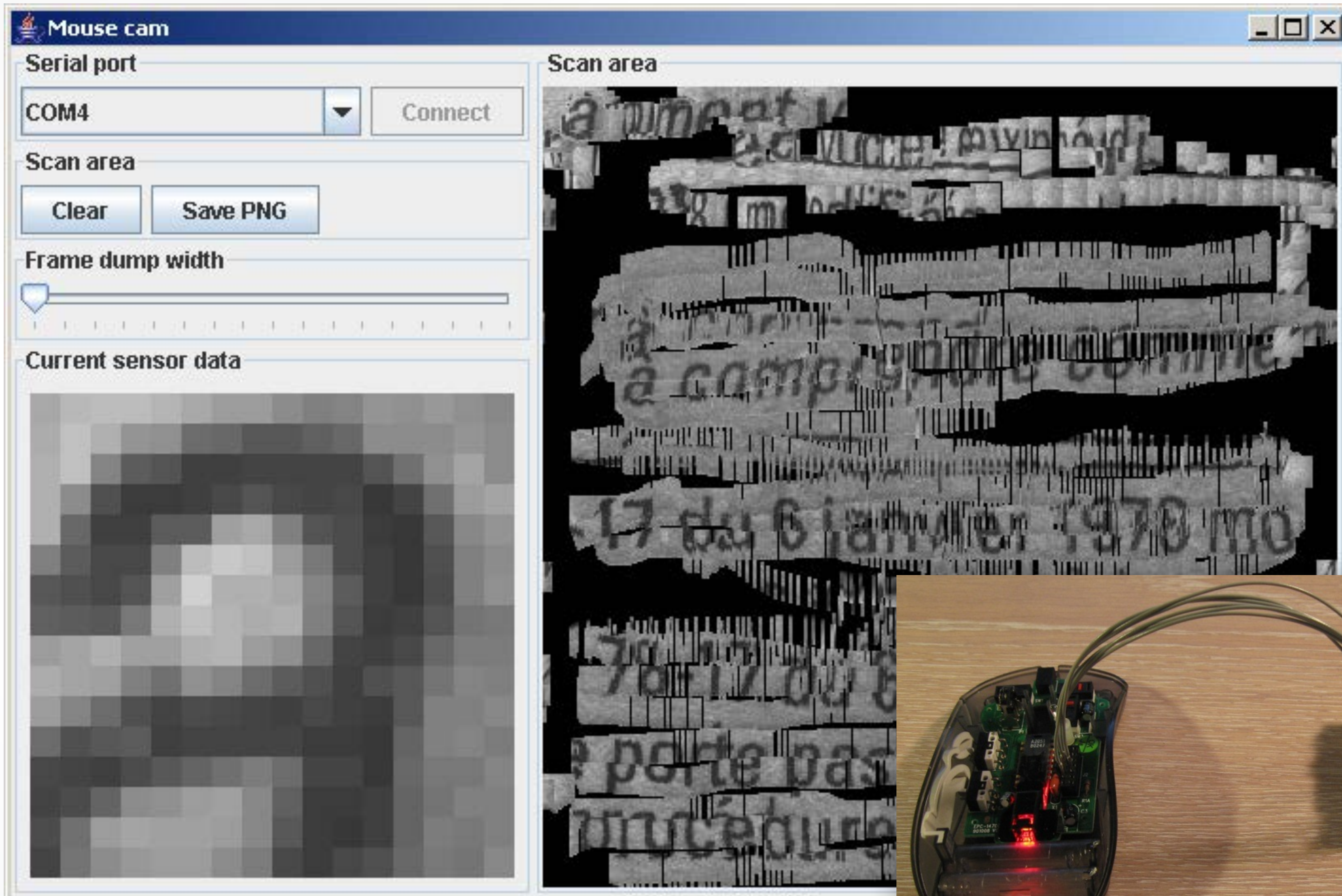


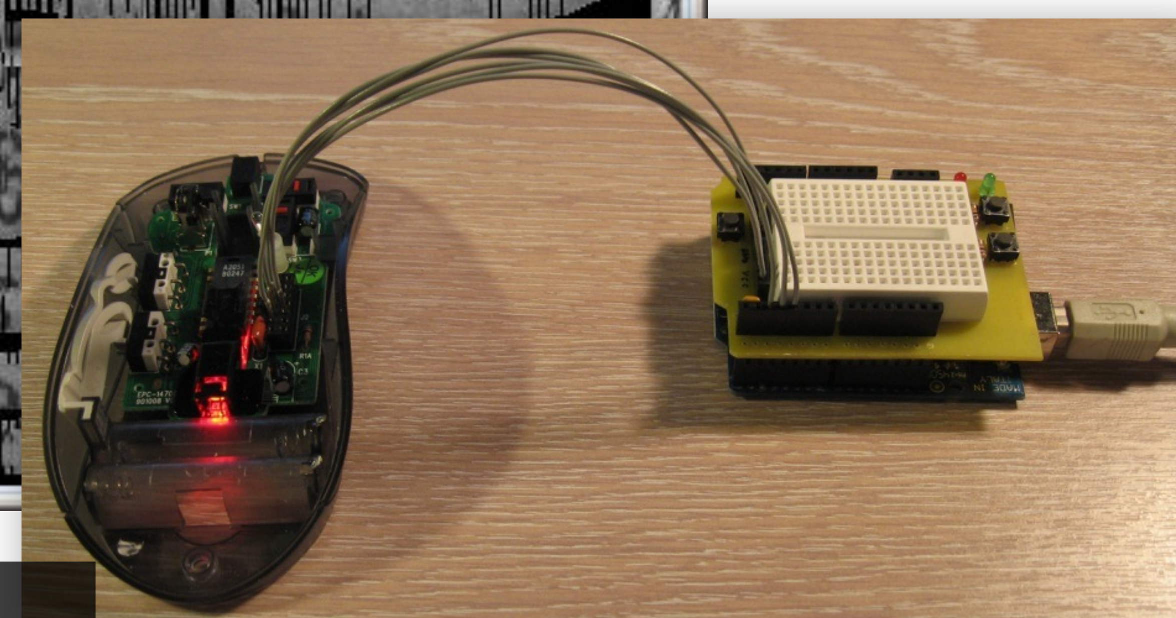


Key press closes circuit; character map used to determine which key (filter bounces)

http://www.headfuzz.co.uk/files/keyboard-matrix2-sch.png
http://graphics.stanford.edu/courses/cs148-11-fall/lectures/input.pdf

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-08dec03.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

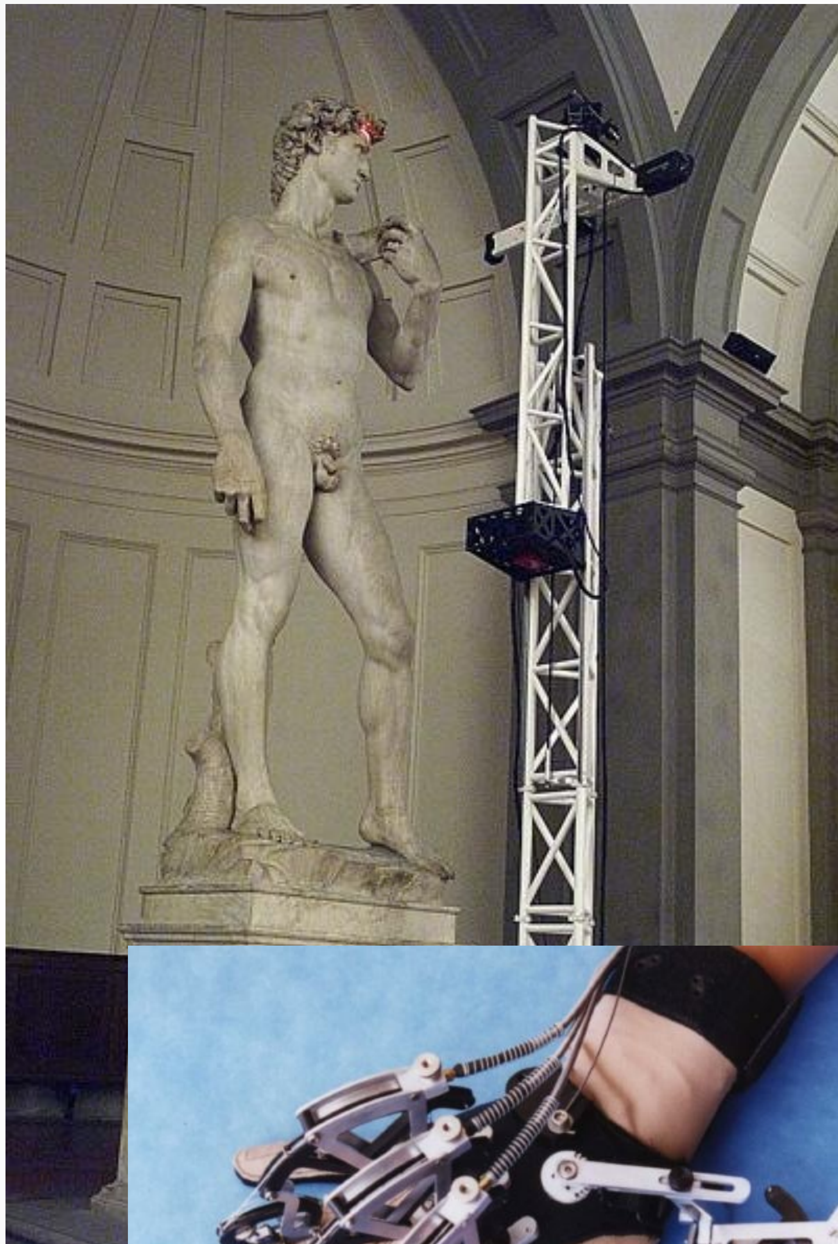
http://0.tqn.com/d/compactiongames/1/0/J/A/1/gp2.jpg
https://images-na.ssl-images-amazon.com/images/G/01/videogames/detail-page/B0045FGET2.01.lg.jpg

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

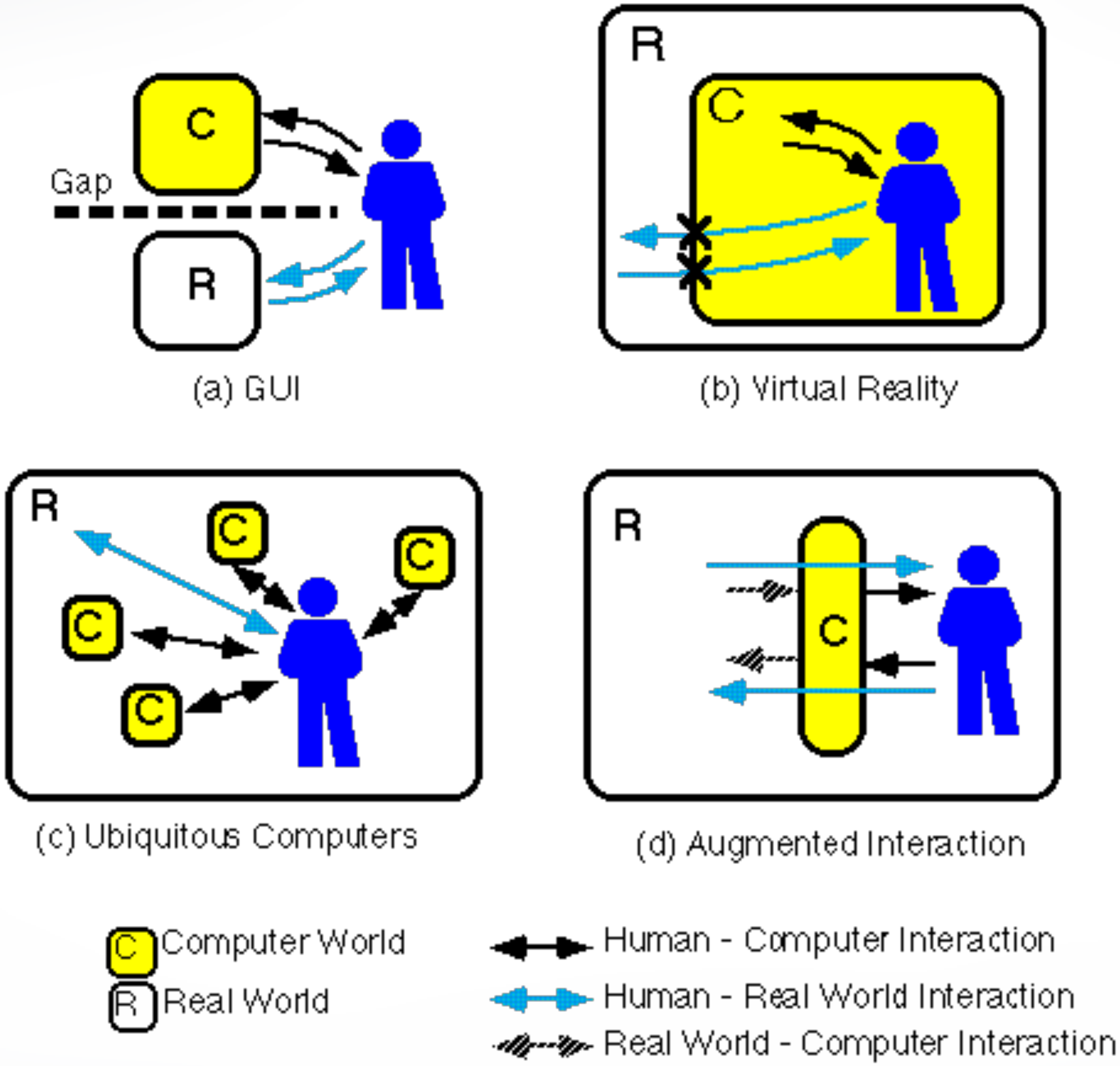
Technological Trends

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

Technology becomes invisible

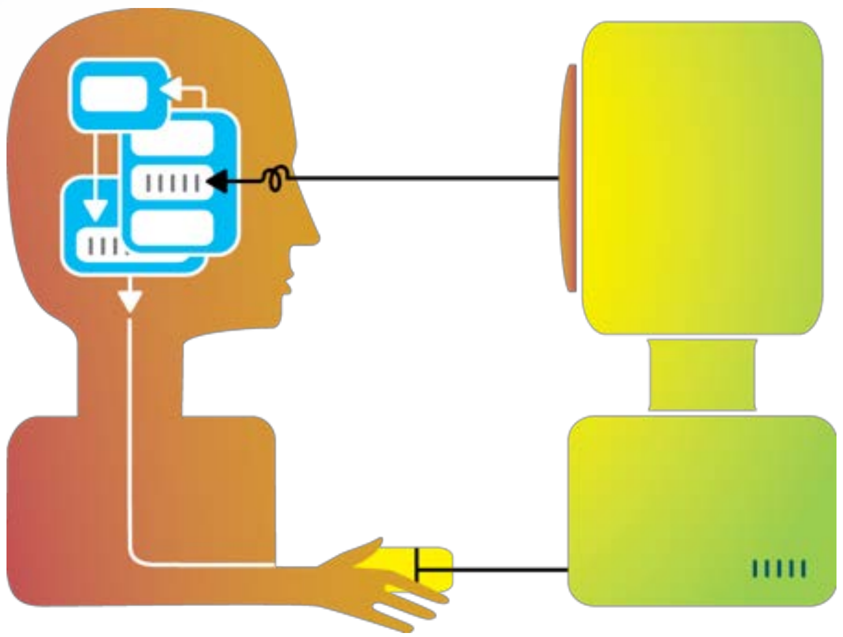
- Intuitive to use
- Interface over internals
- Form over function
- Human centered design

Invisible Interfaces



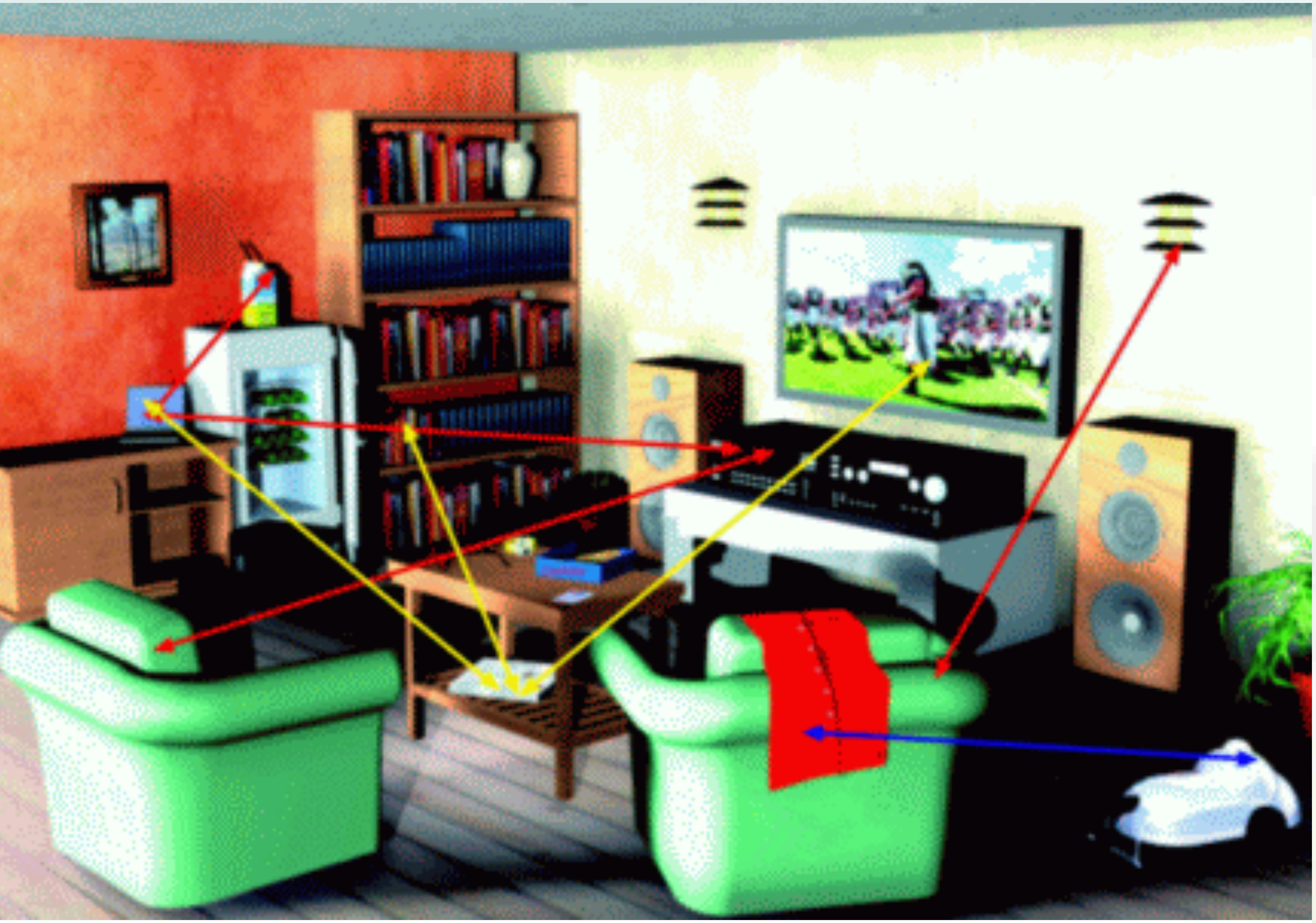
Jun Rekimoto, Sony CSL

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…

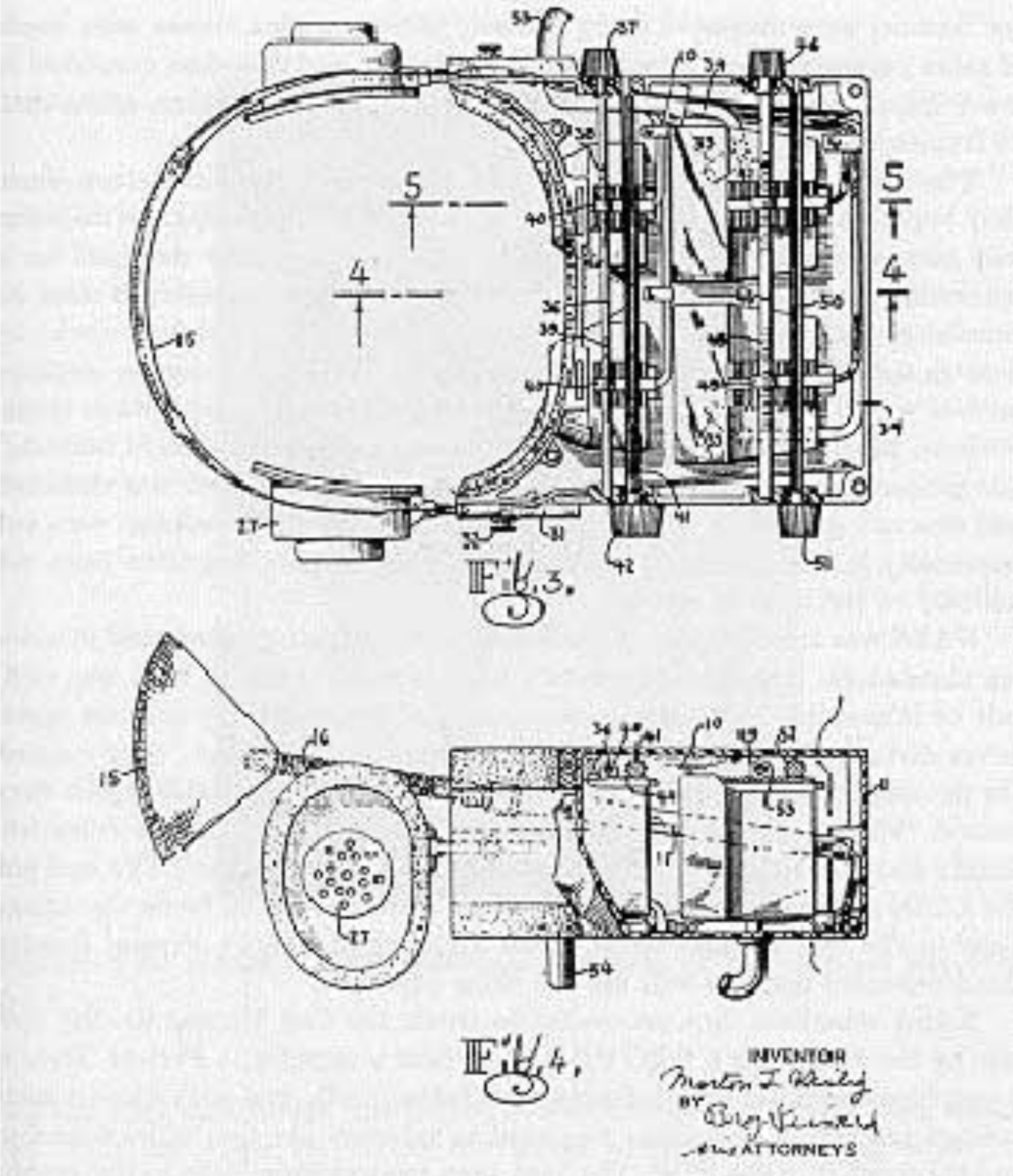
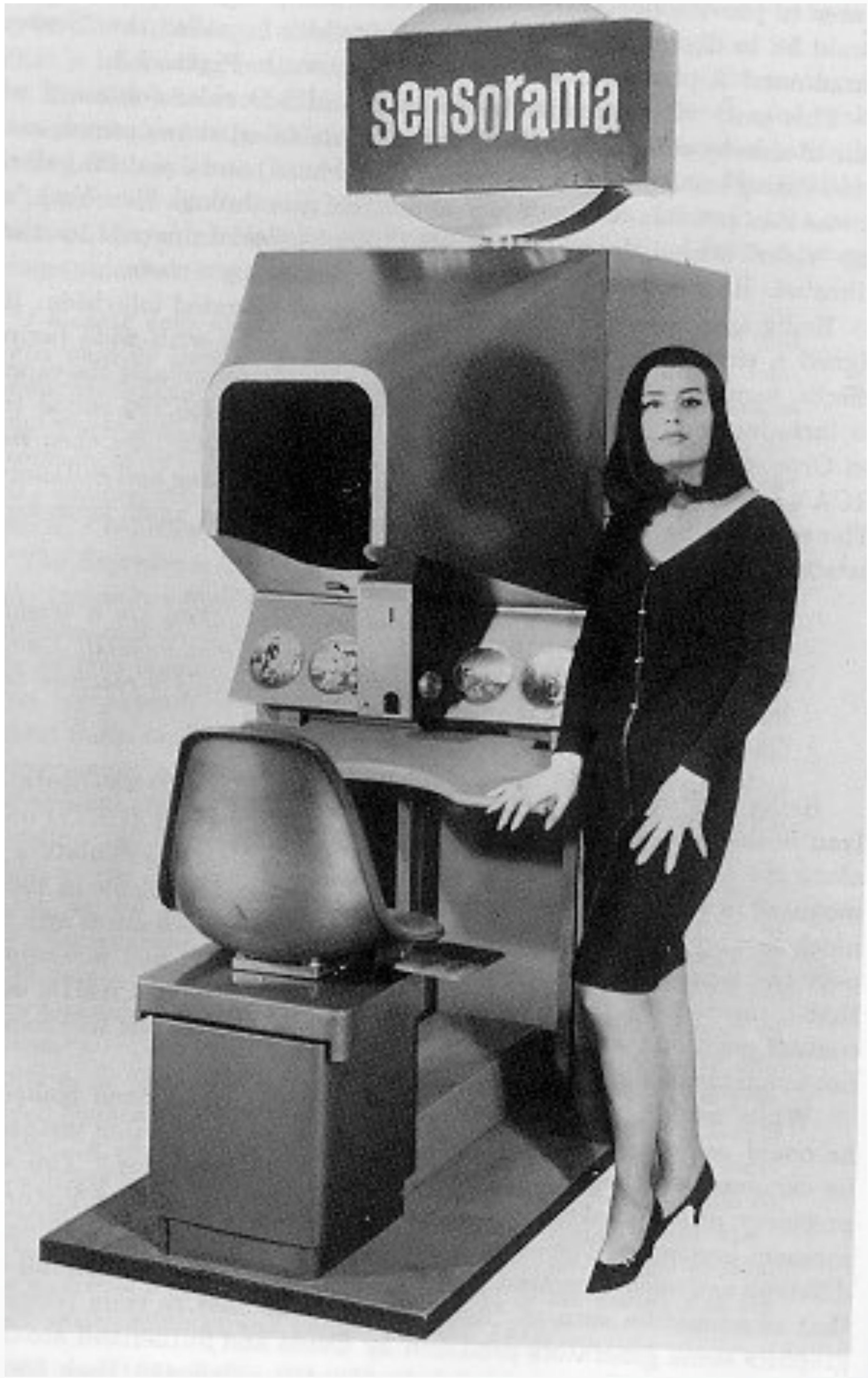


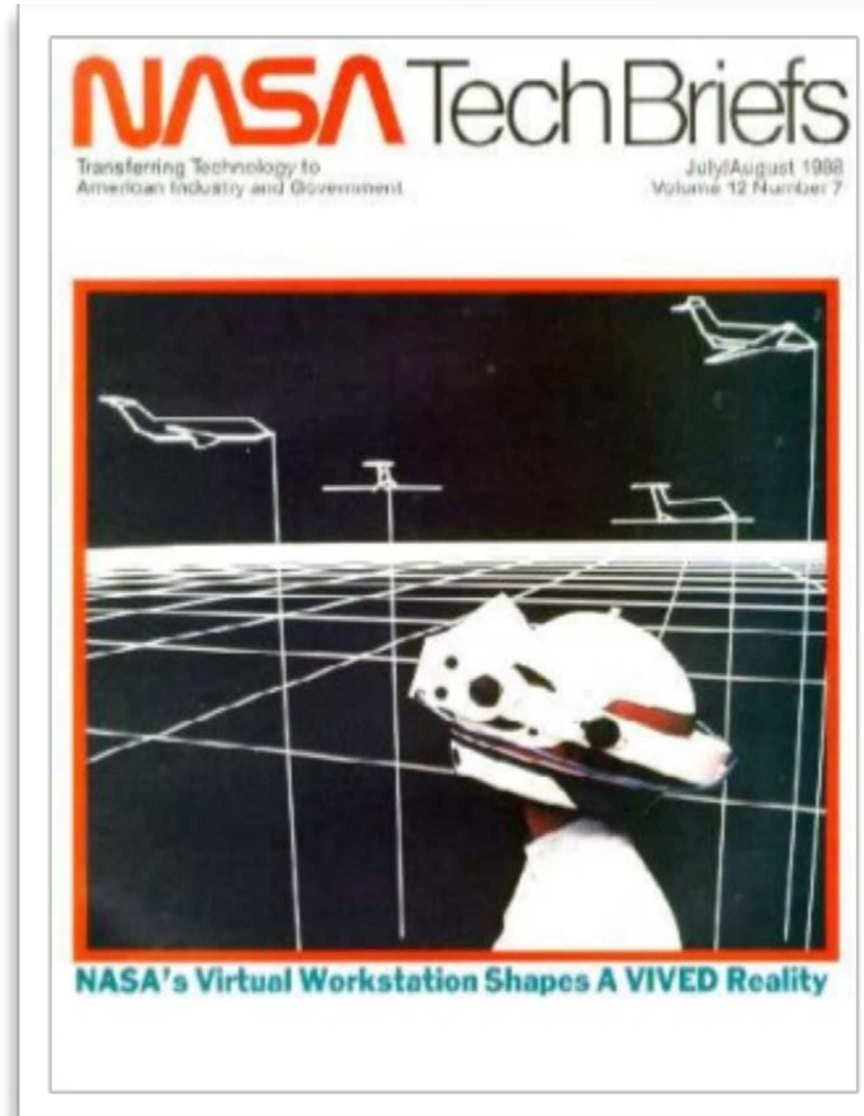
Figure 1.4: *Heilig's early Head-Mounted Display patent [Heilig 1960].*

Virtual Reality

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

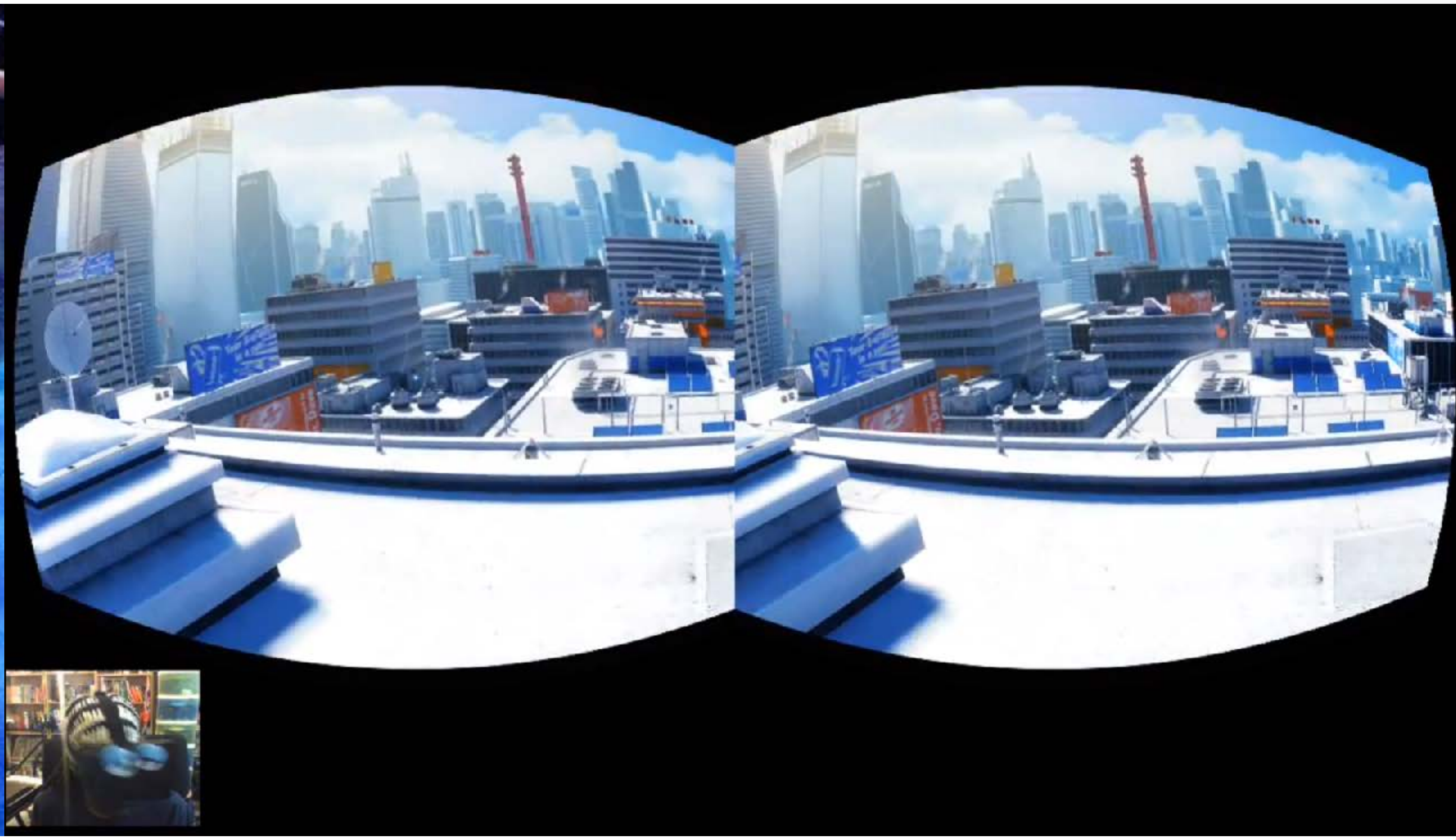


Virtual Reality



- 1985…

Virtual Reality

Immersive VR

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

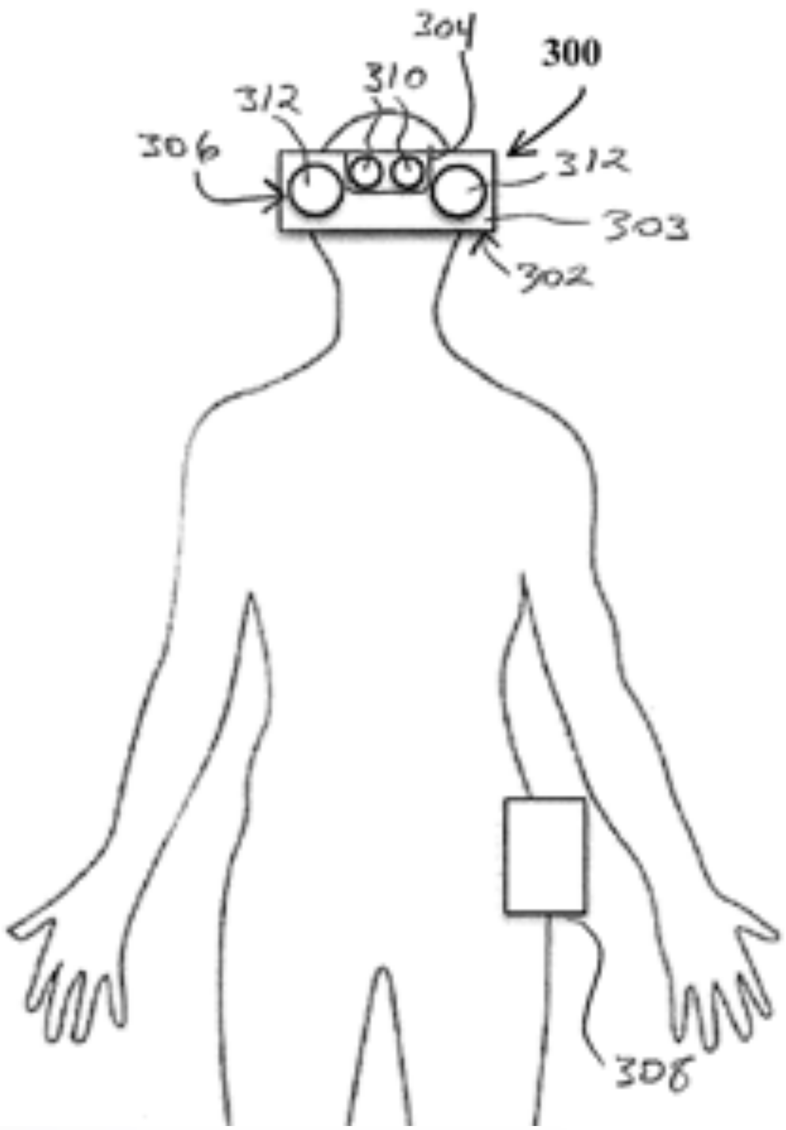
Augmented Reality

Defining Charactestics [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),

Augmented Reality Examples



Magic Leap

Augmented Reality Examples

Google Glass

VR vs AR

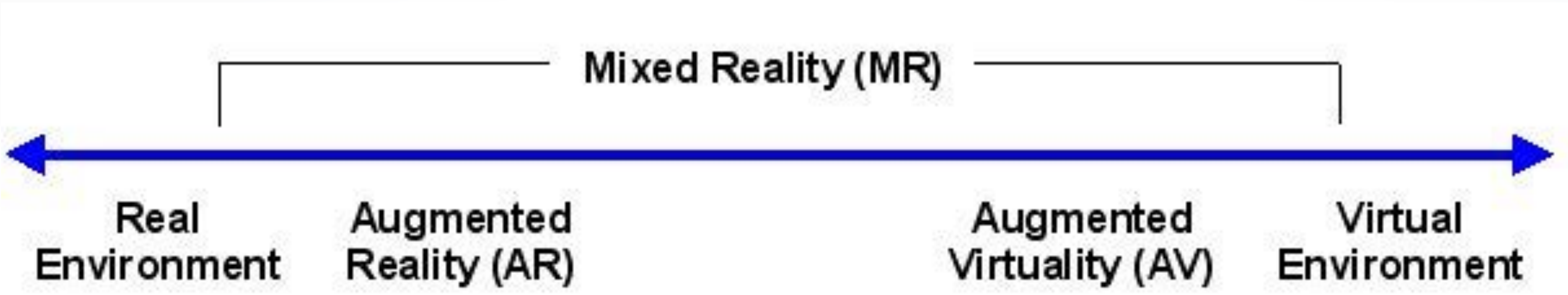
Virtual Reality: Replaces Reality

- 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

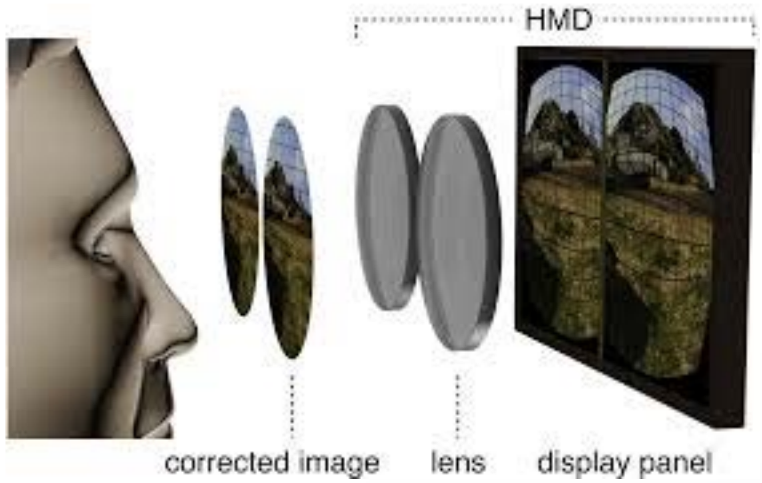
Milgram's Reality-Virtuality Continuum



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

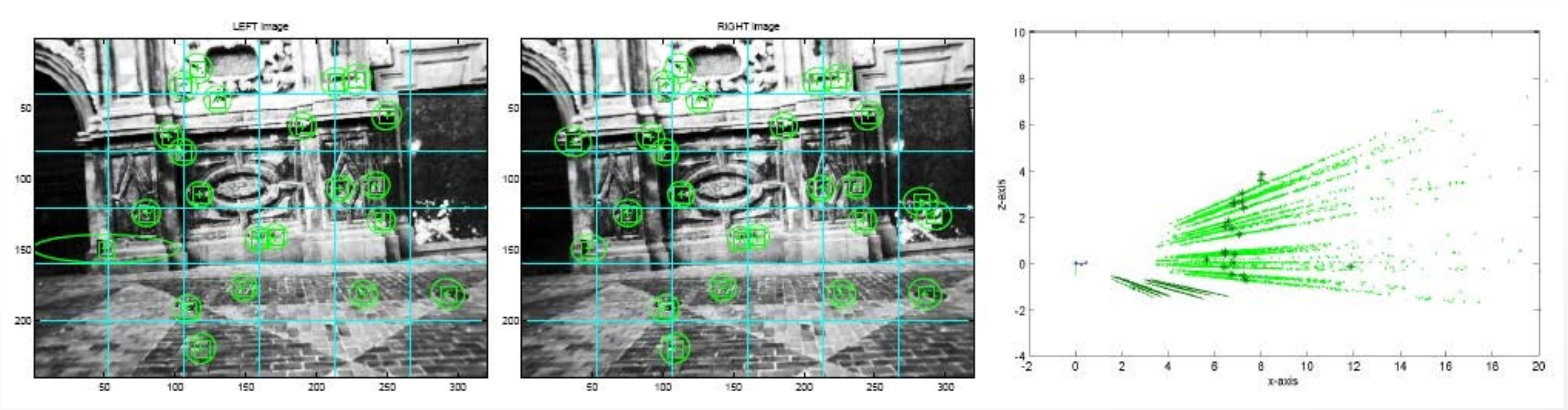


- High-quality realtime 3D content

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

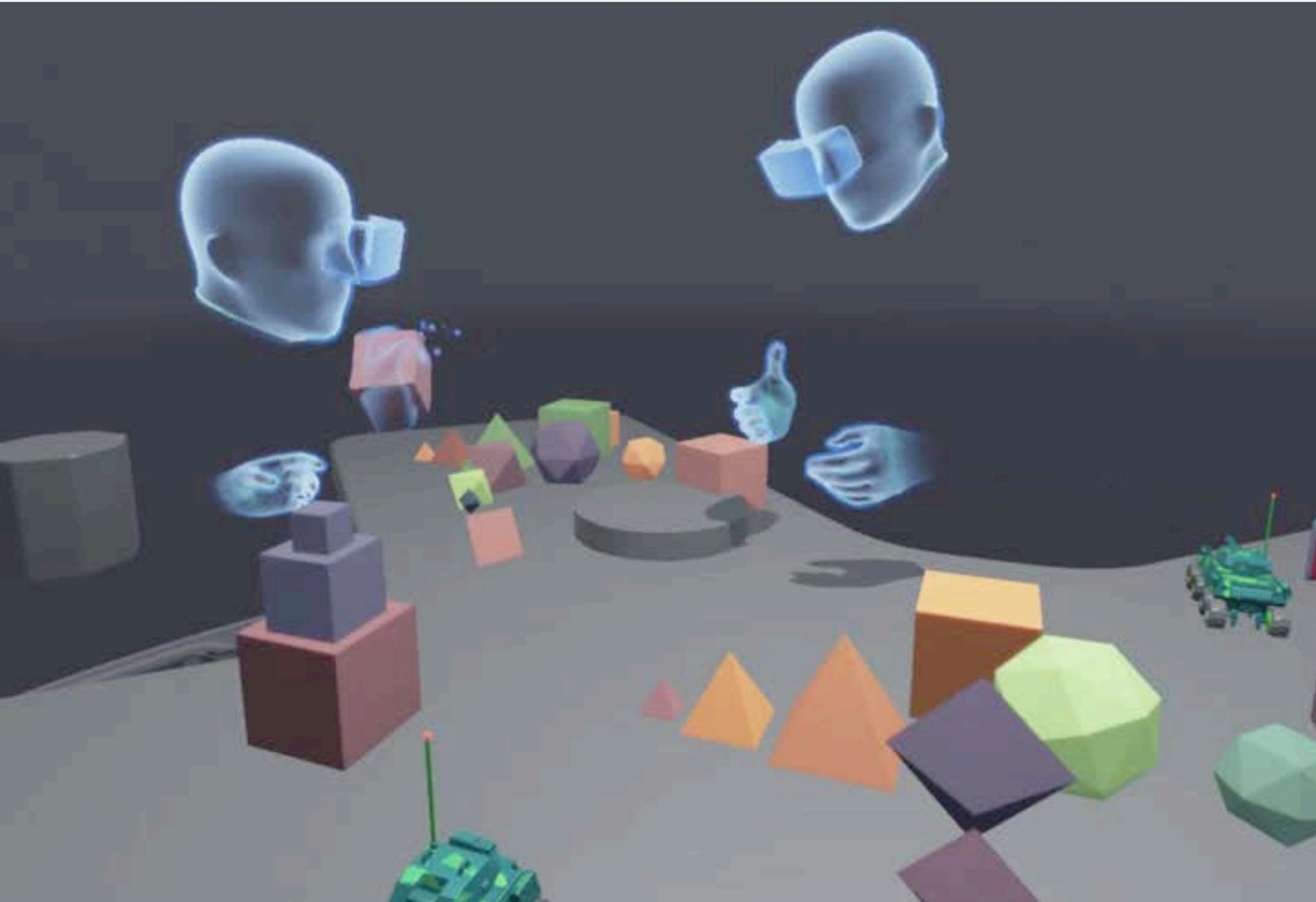


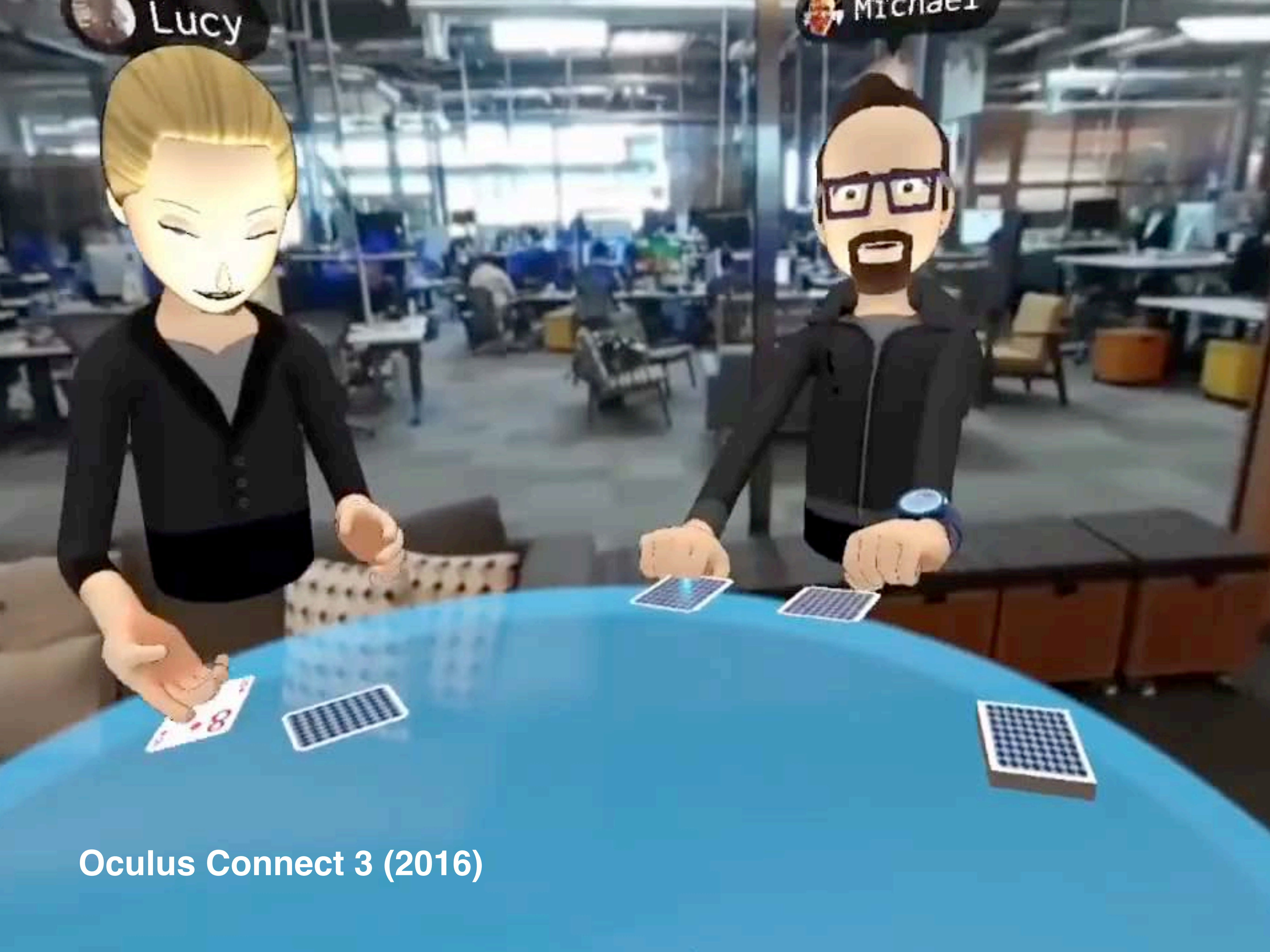
Immersive Experience

Virtual Reality **Reloaded**

Oculus VR 2012 / Crytek 2014

Social Interactions in Cyberspace

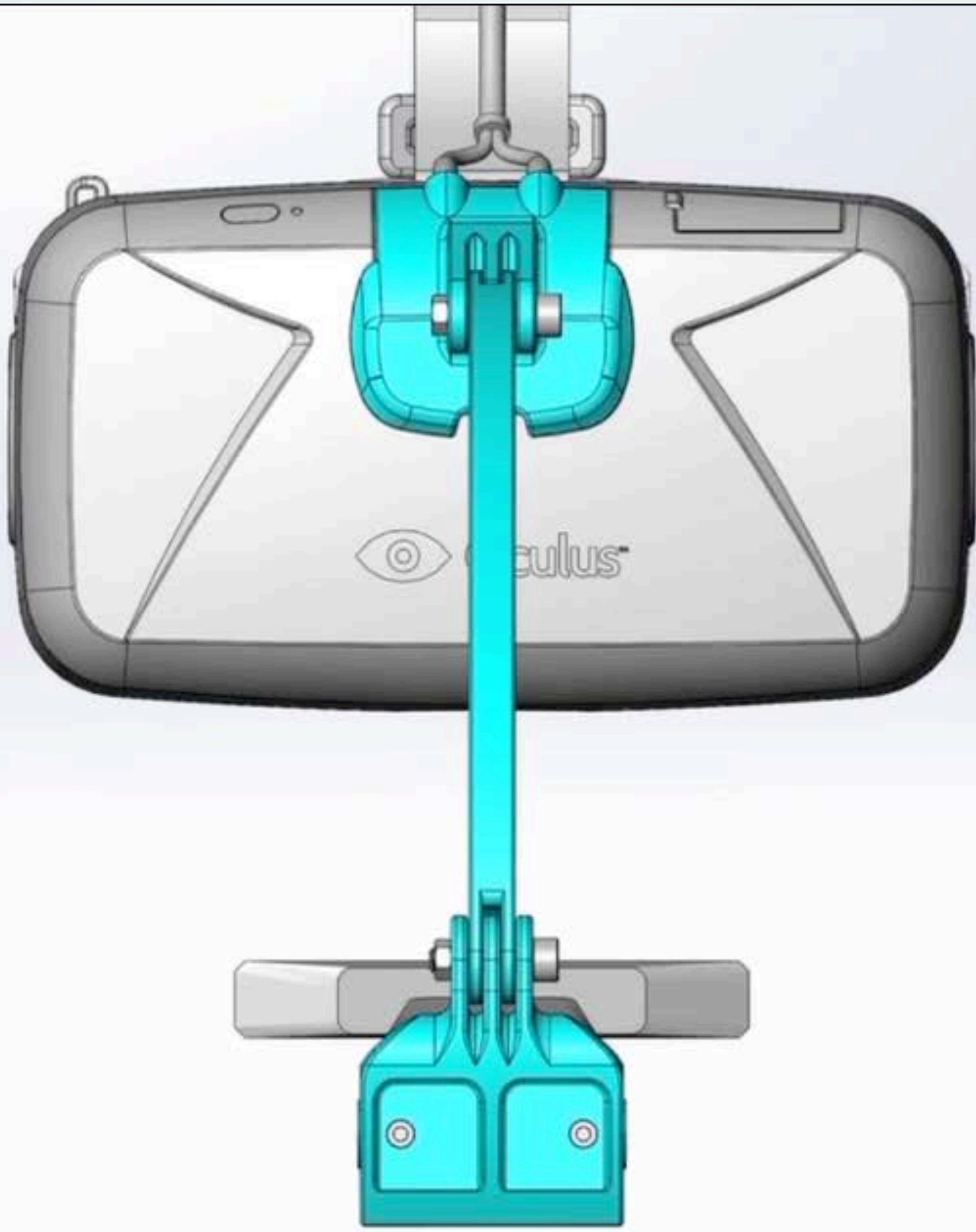




Oculus Connect 3 (2016)

Occlusions

Facial Performance Sensing HMD

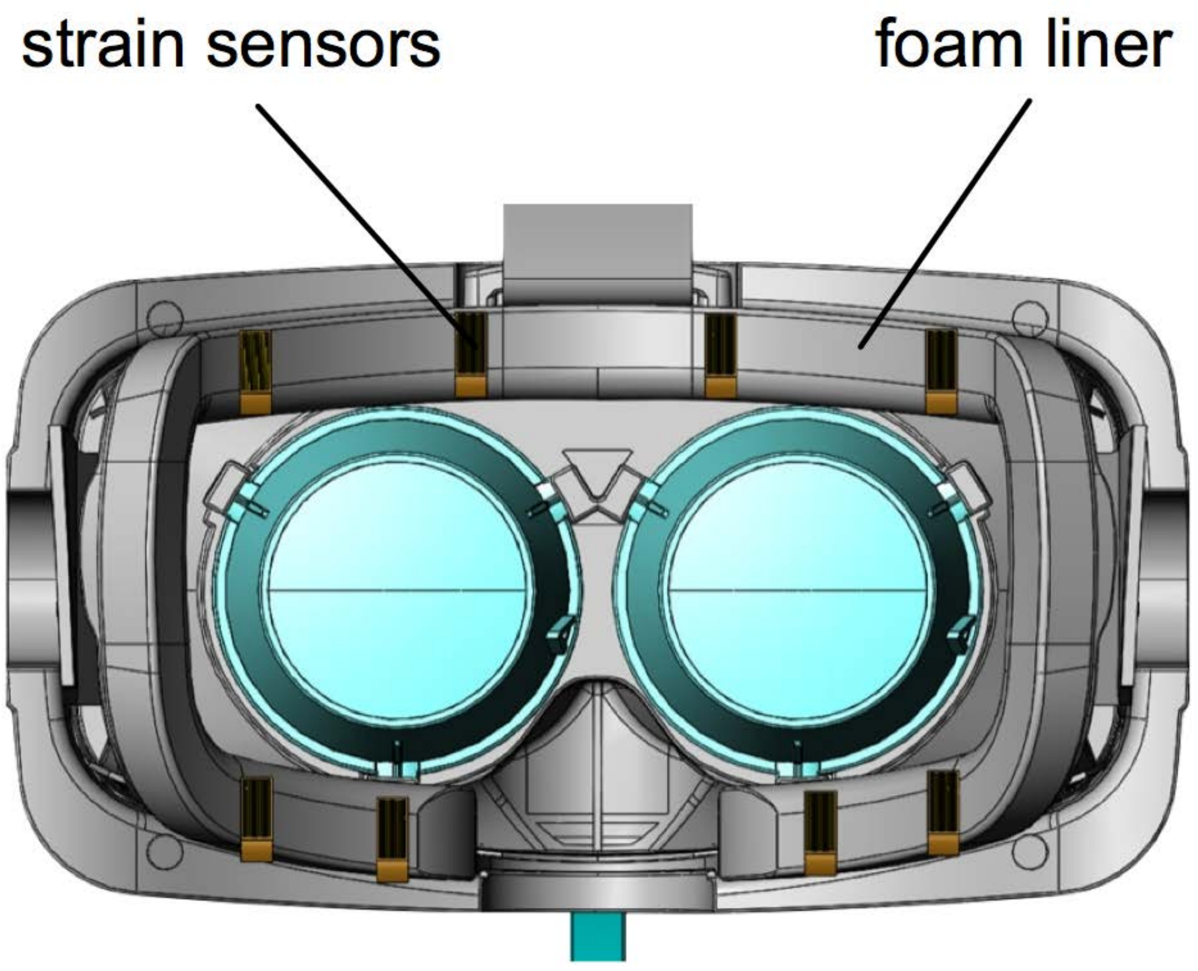


Facial Performance Sensing HMD

OLED display
and cover

RGB-D camera
(Intel IVCAM)

Facial Performance Sensing HMD

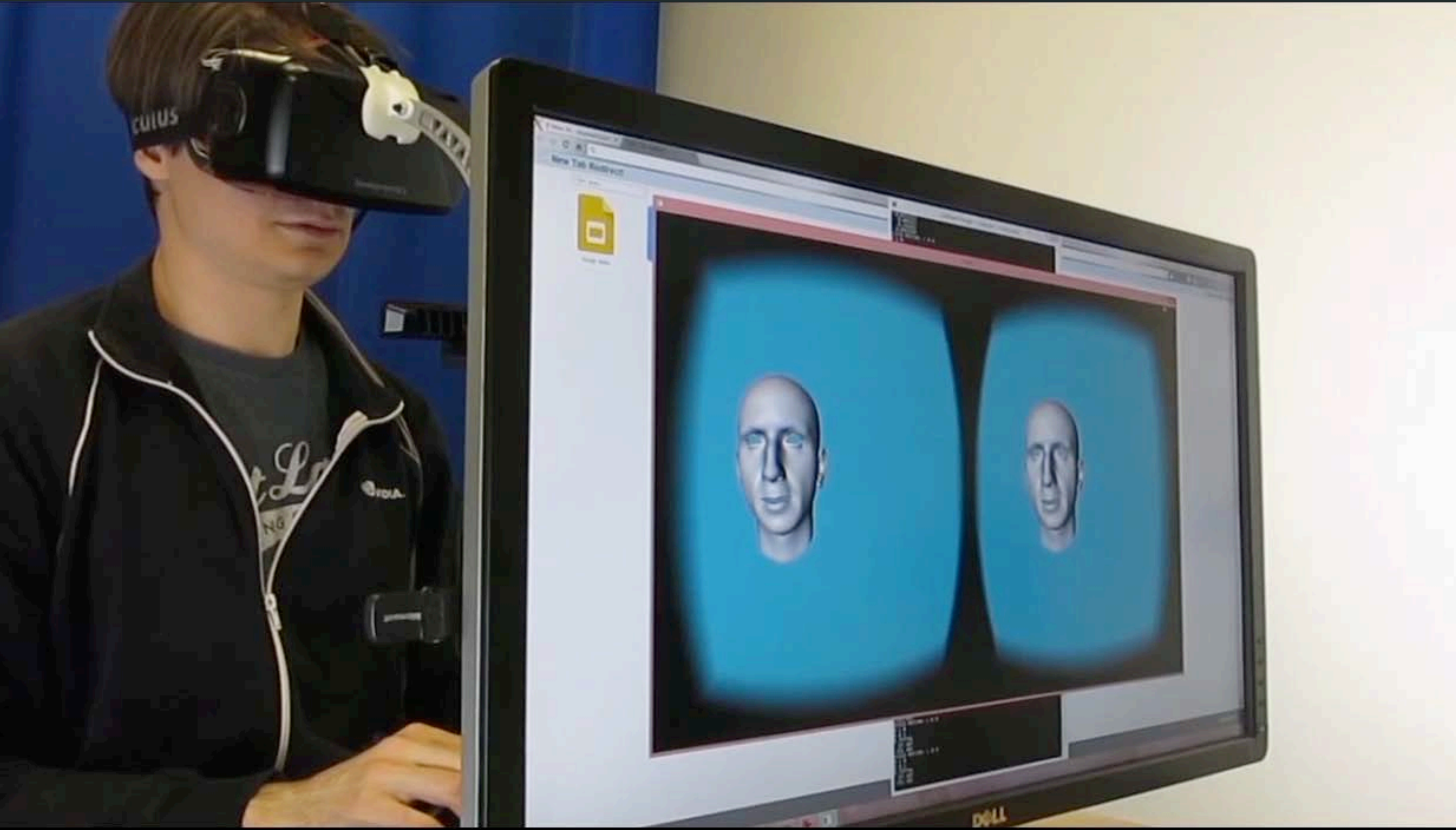


interior
(CAD model)

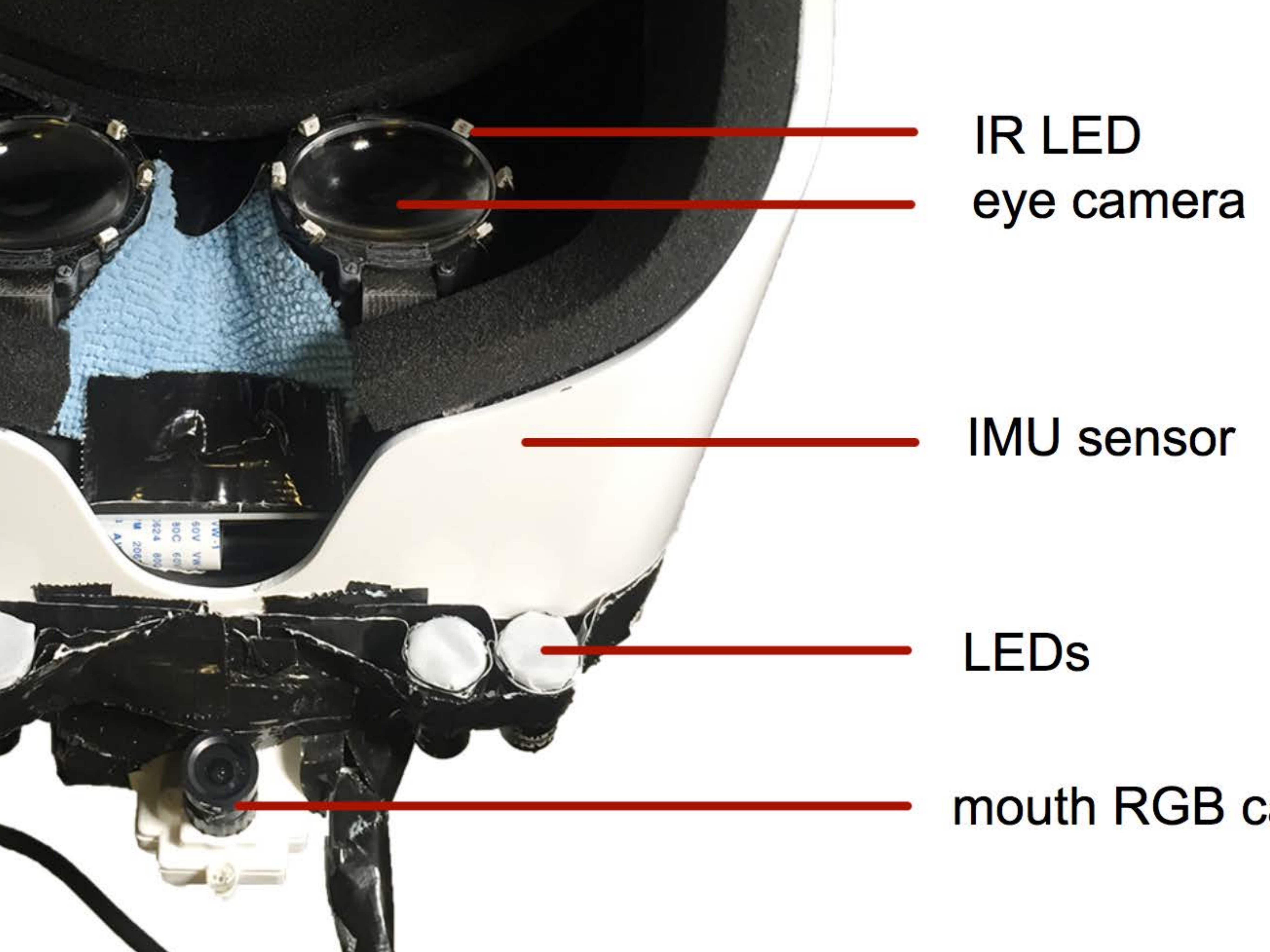
Facial Performance Sensing HMD

Ultra Thin Flexible Electronic Materials

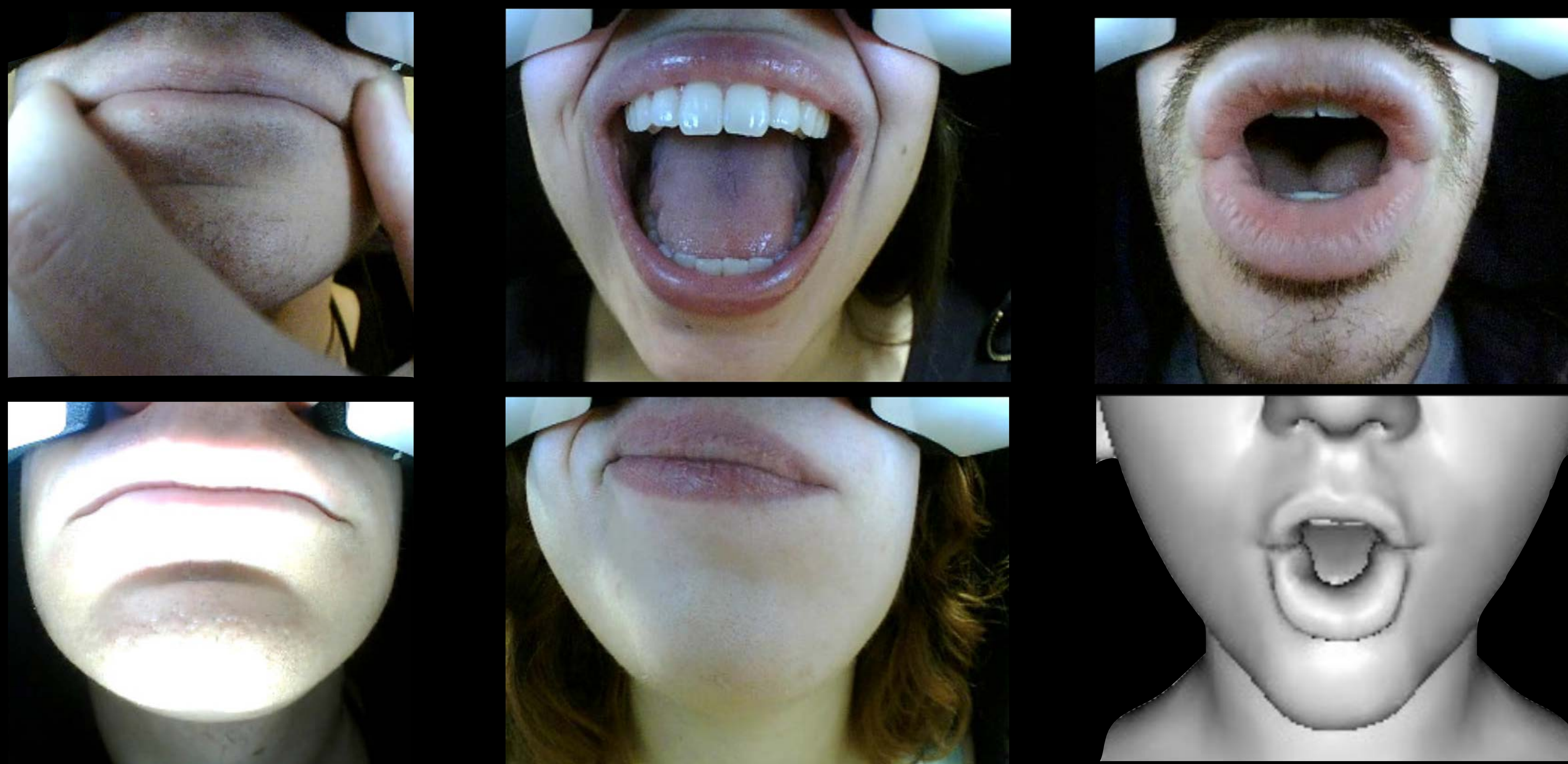
Live Demo



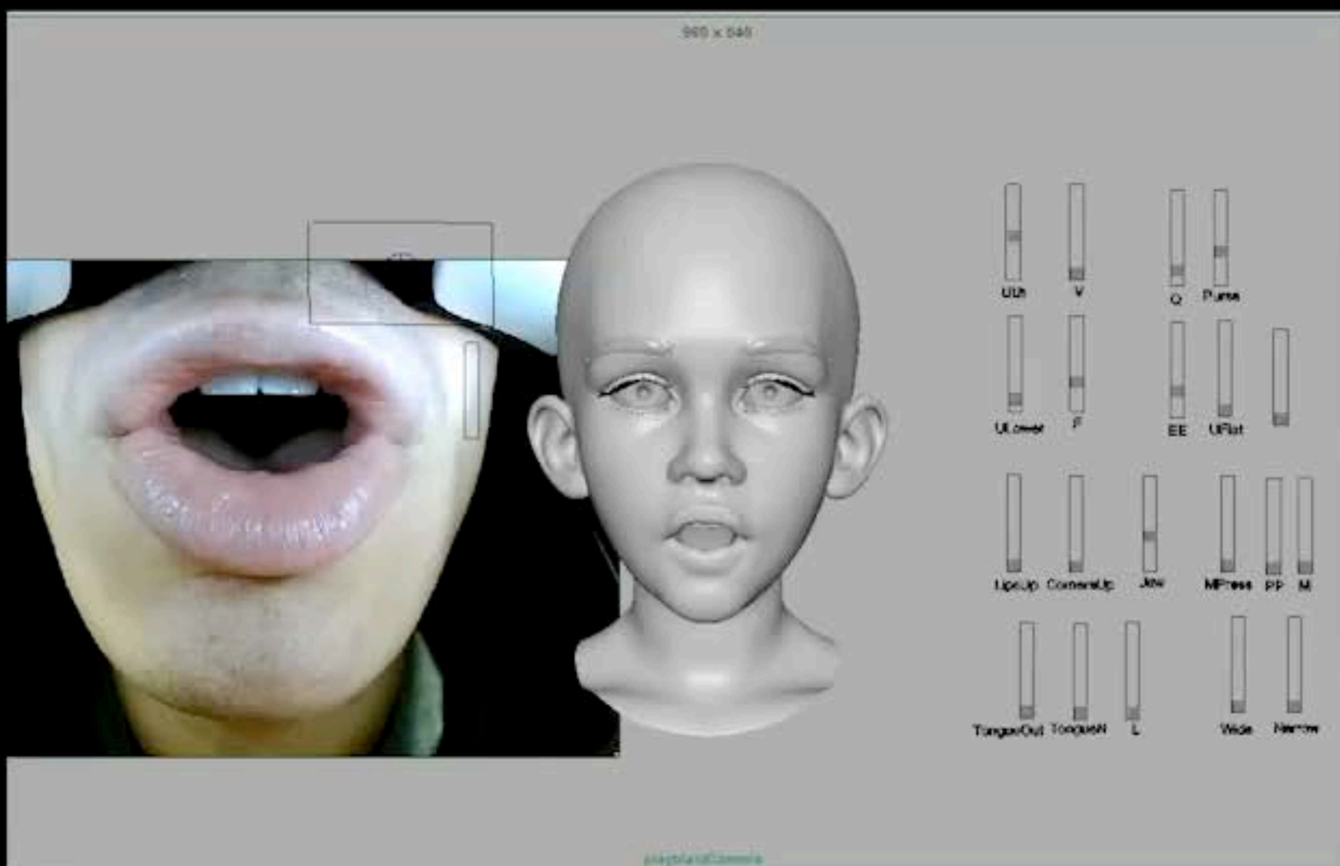
Olszewski et al. (2016)


IR LED
eye camera
IMU sensor
LEDs
mouth RGB c

High Dimensionality & Non-Linearity



Training via Audio Alignment



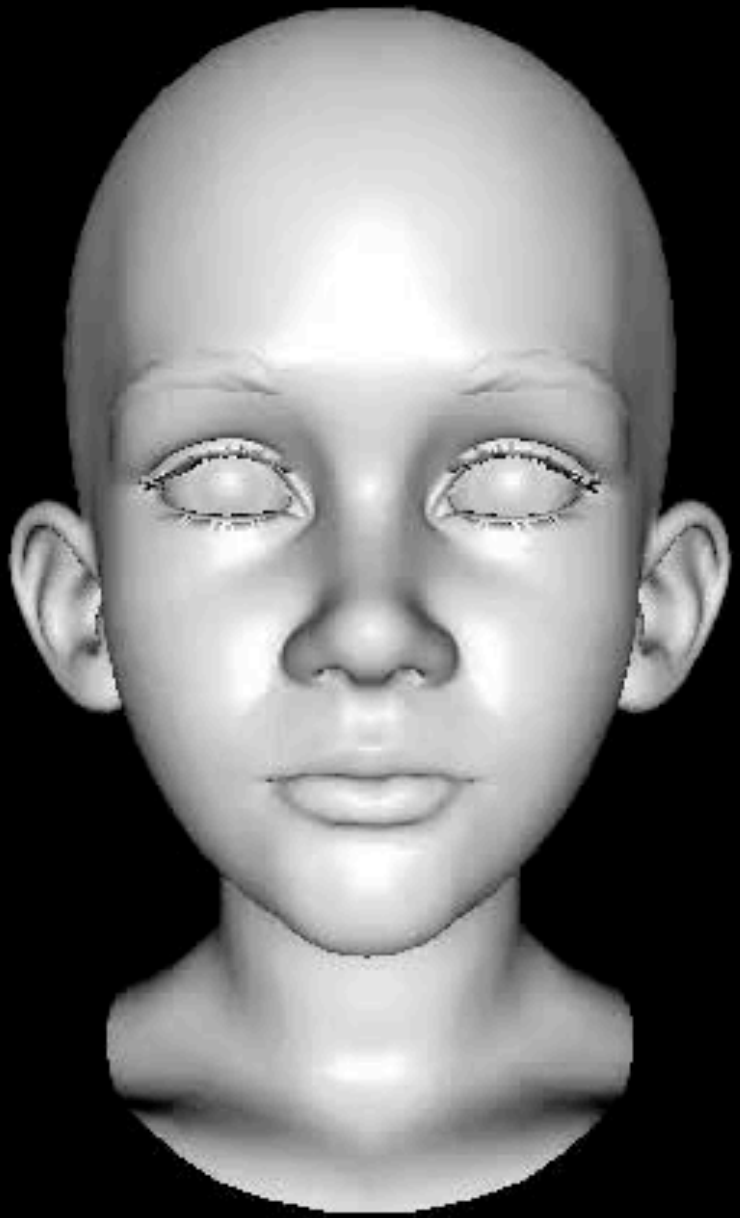
reference data

reference animation

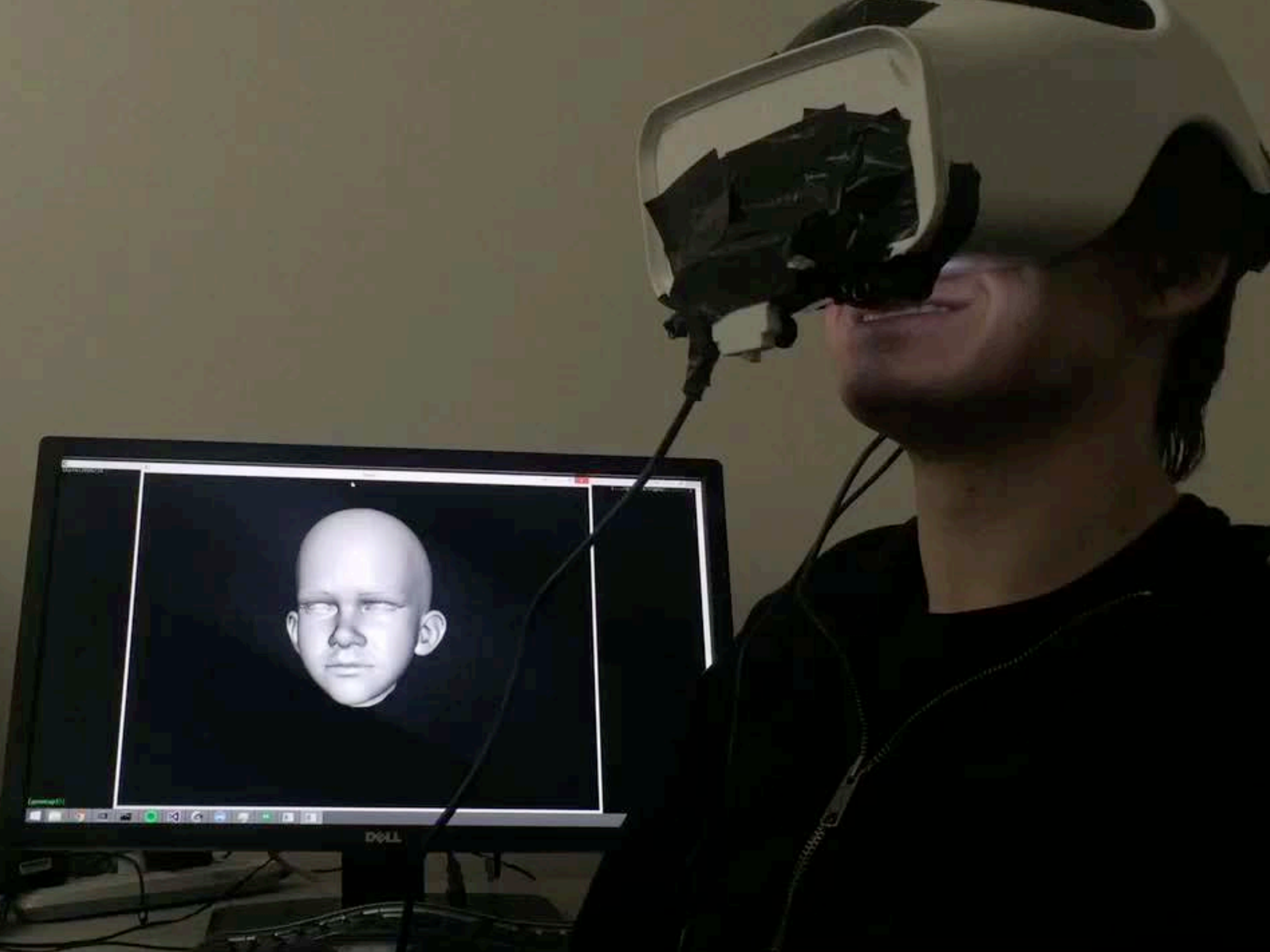
dynamic time warped training data

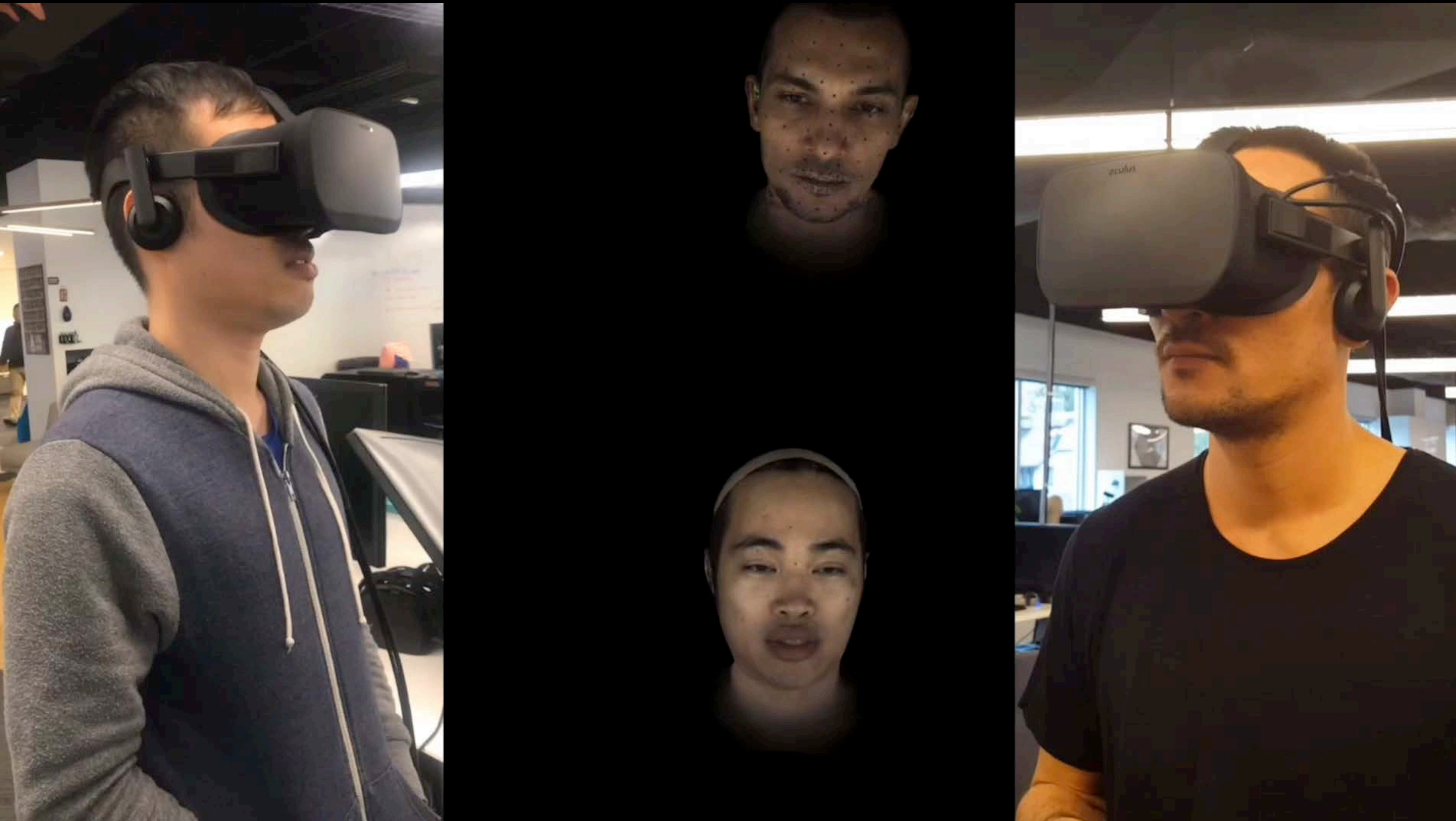
Mouth Animation

input video



output animation





Input: 40 camera streams

Output: Data-Driven Avatar

Digital Humans

VFX Production

Weta Digital (2014)

Game Production

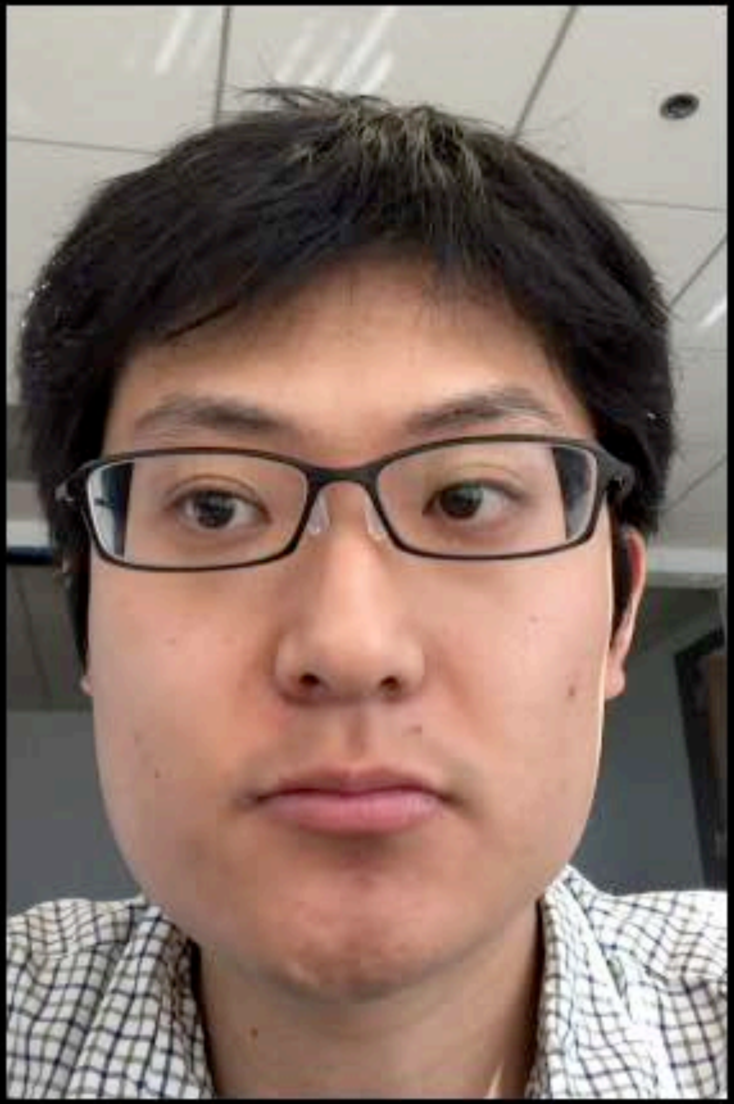
ic Games / Cubic Motion / 3Lateral (2018)

Pinscreen (2017)

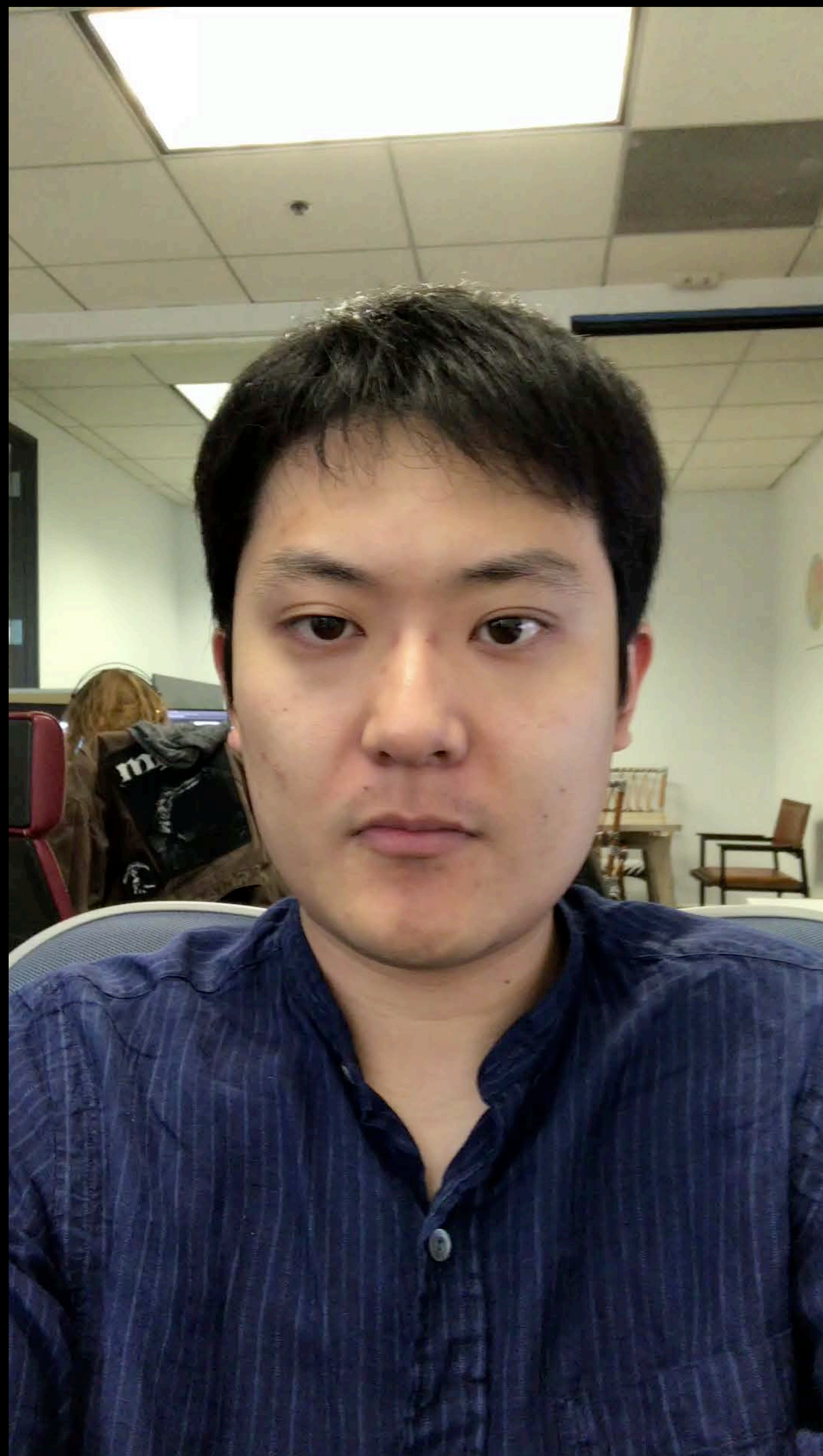
Real-Time Lighting Estimation

NextGen Photoreal Avatars

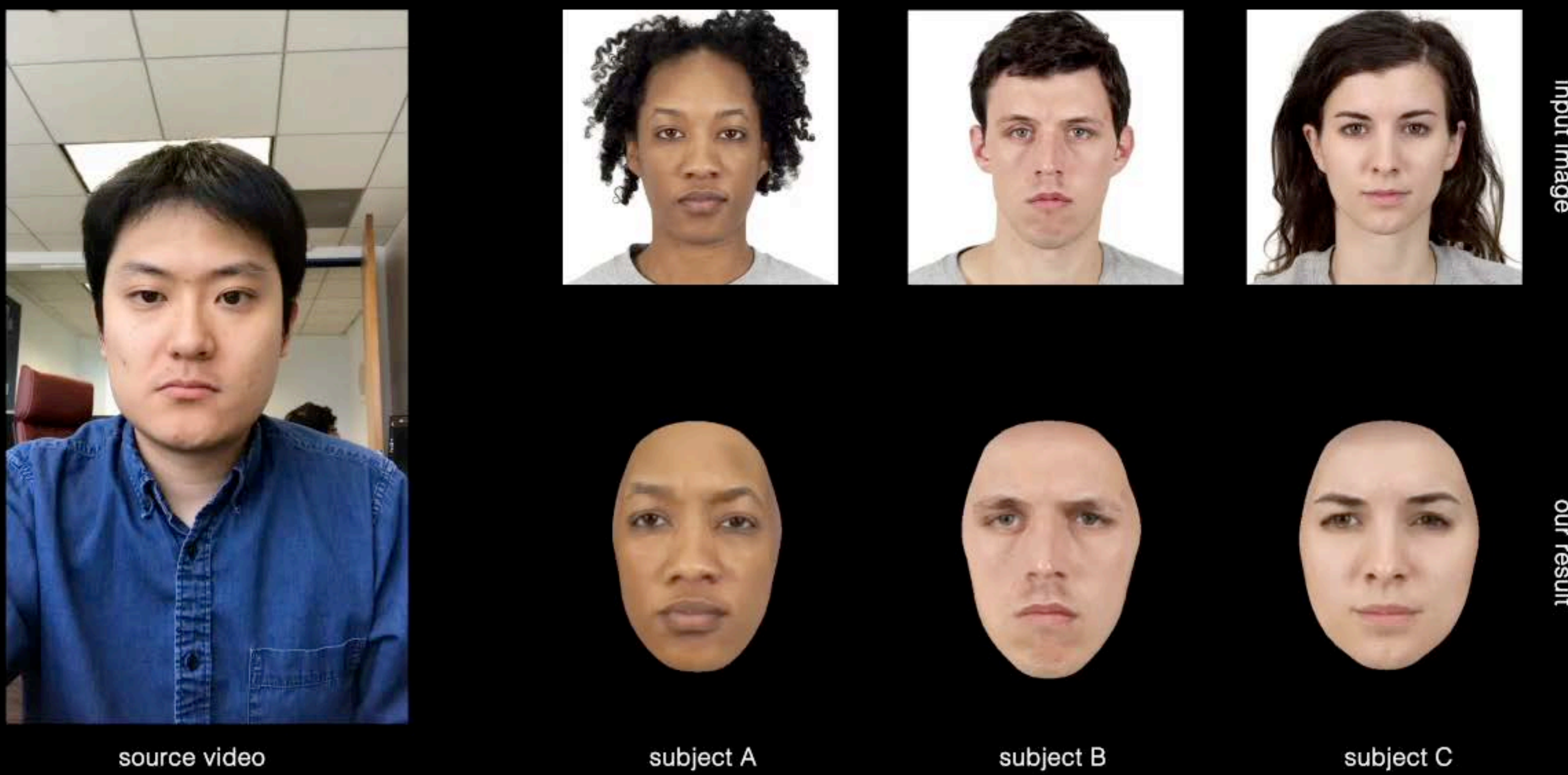
Deep Learning-Based Face Synthesis



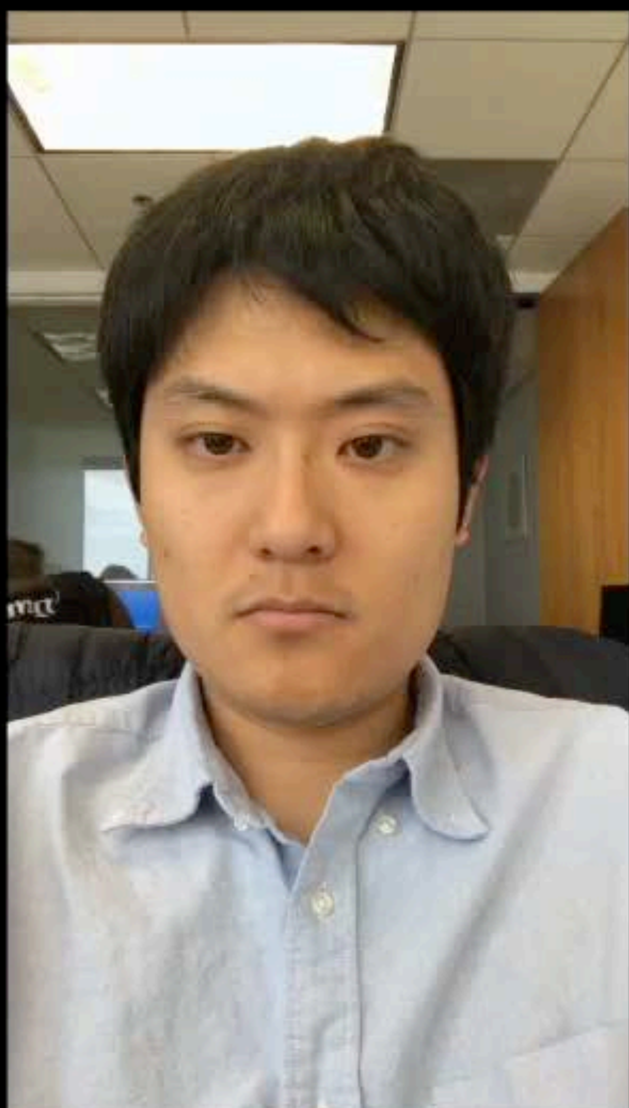
Deep Learning-Based Face Synthesis



Deep Learning-Based Face Synthesis



Deep Learning-Based Face Synthesis


source video


subject A


subject B


subject C


subject D


subject E


subject F


Hair **Modeling**

frontal 01

Reference photo

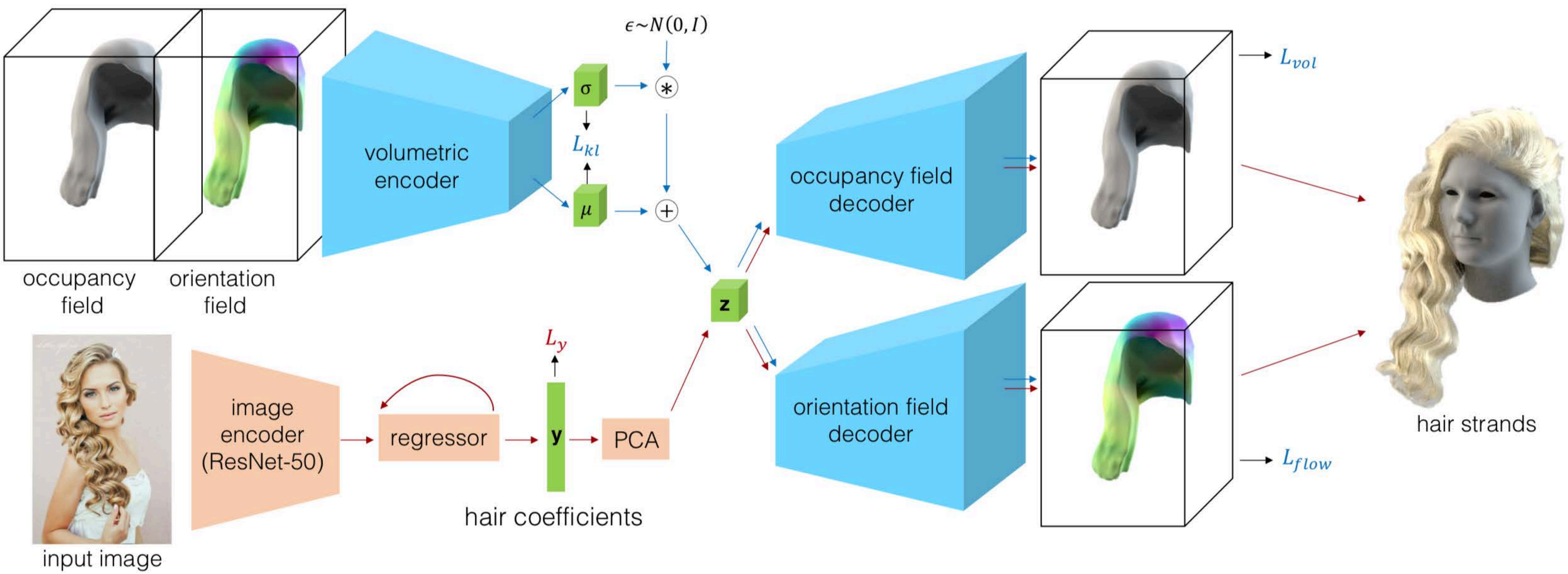
Our result

Reference photo

Five-strand Dutch braid

Our result

Deep Learning for Hair Modeling



Saito et al. (2018)

Deep Learning for Hair Modeling

input image   predicted volume   output strands

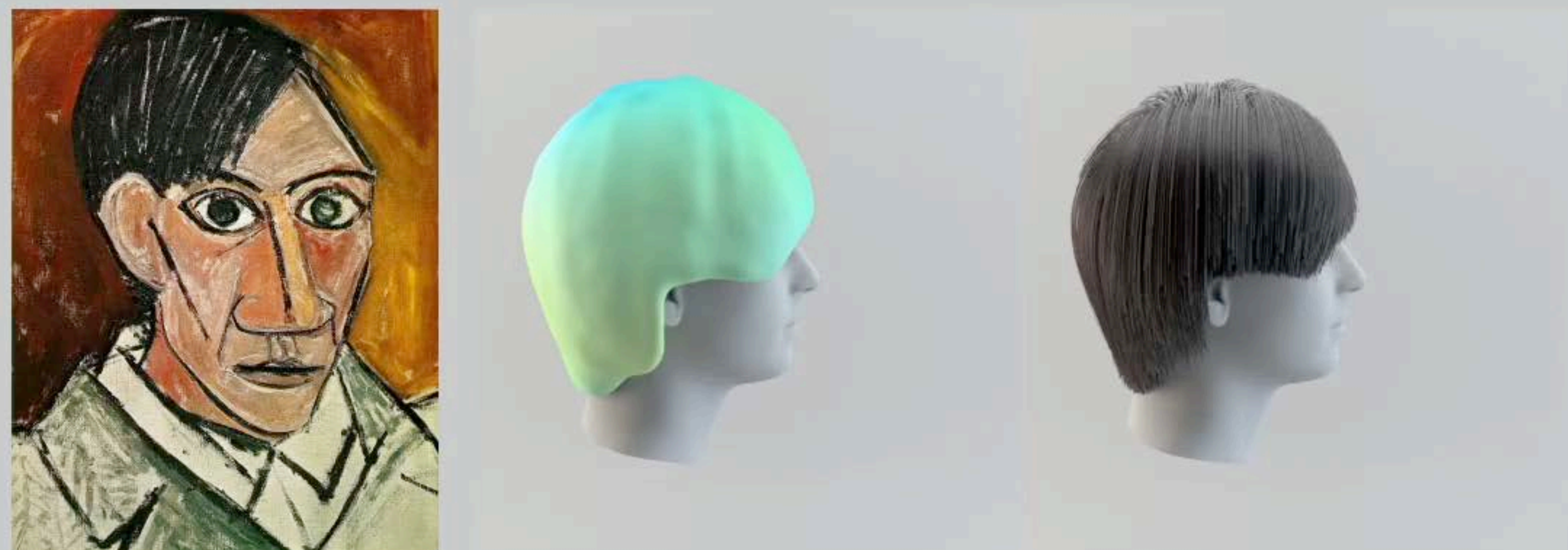
Saito et al. (2018)

Deep Learning for Hair Modeling

Deep Learning for Hair Modeling

Saito et al. (2018)

Deep Learning for Hair Modeling



input image predicted volume output strands

Saito et al. (2018)

Deep Learning for Hair Modeling

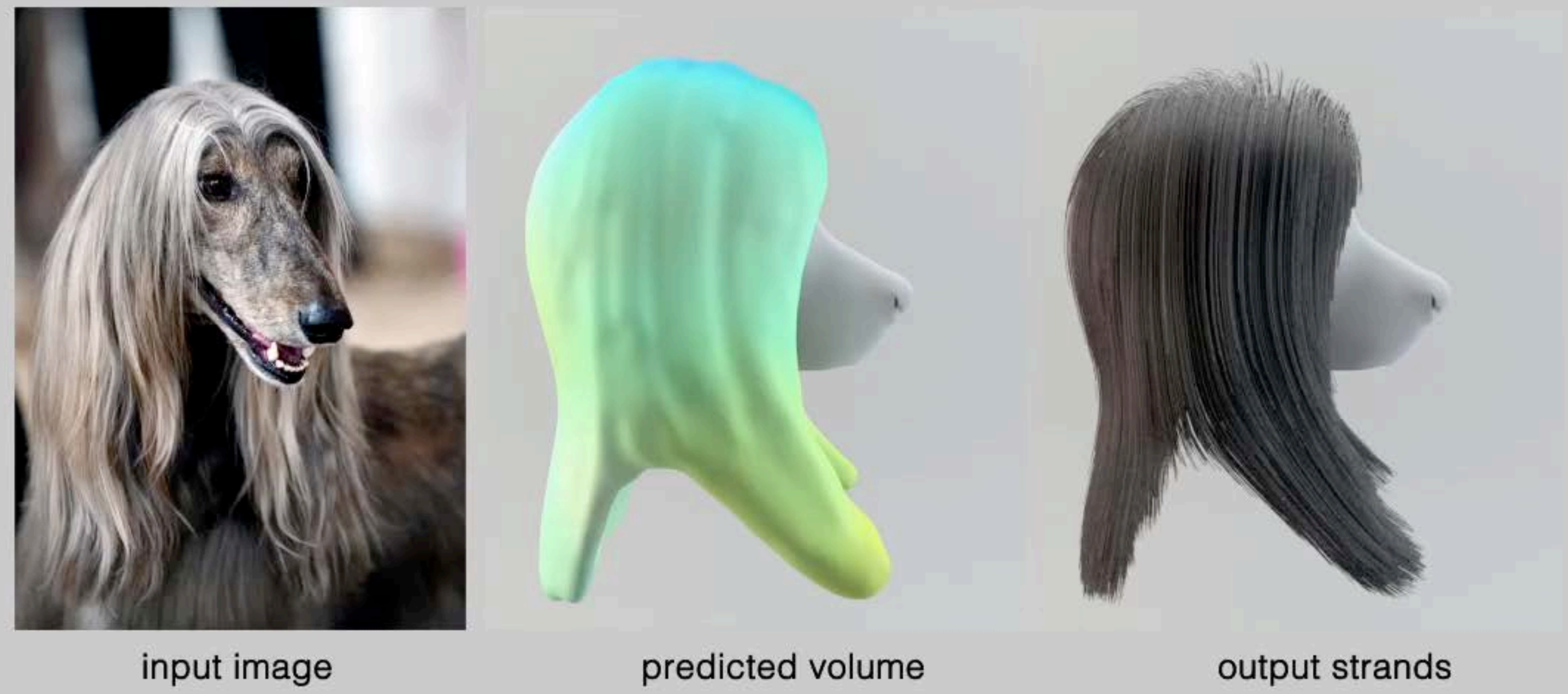
input image

predicted volume

output strands

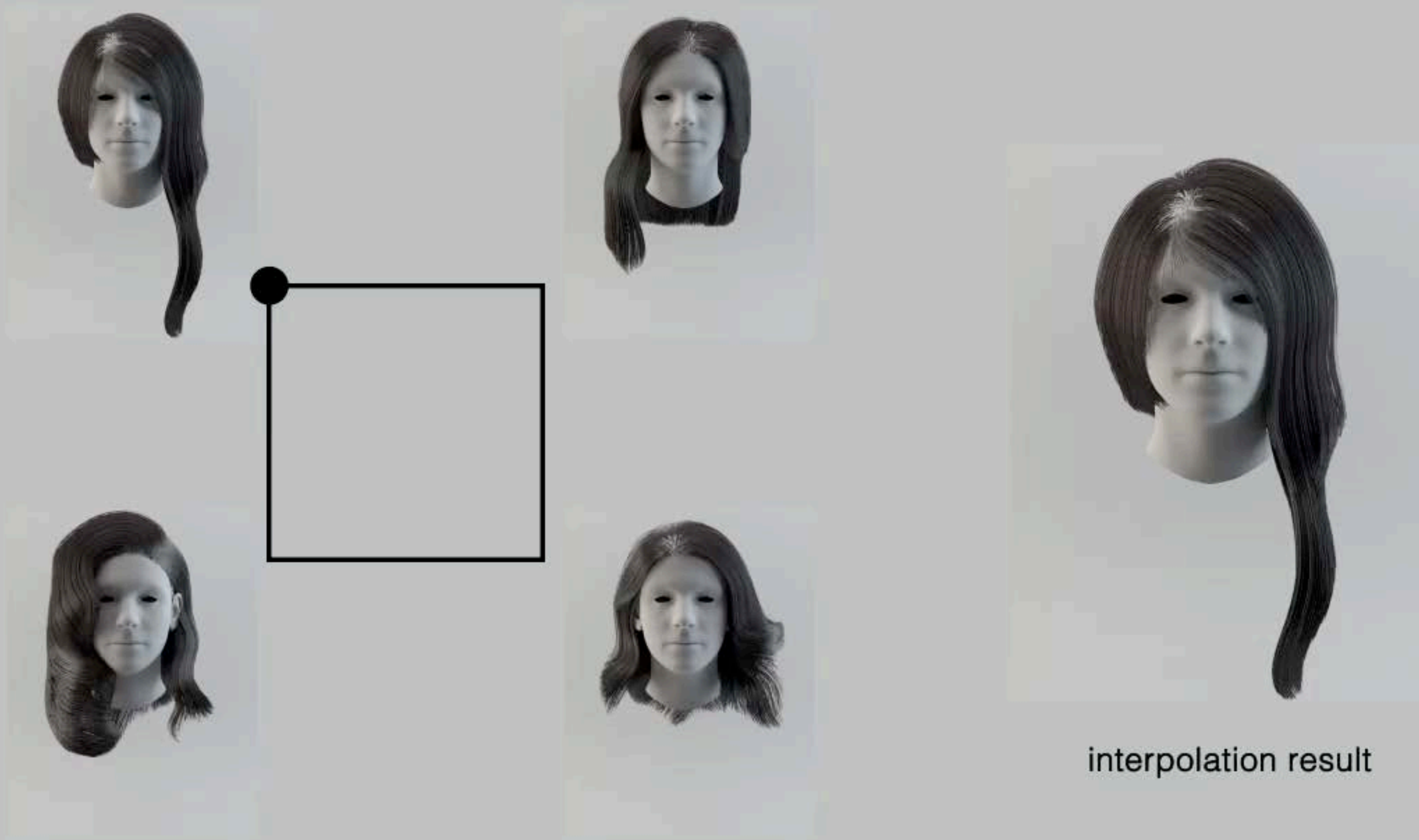
Saito et al. (2018)

Deep Learning for Hair Modeling



Saito et al. (2018)

Deep Learning for Hair Modeling



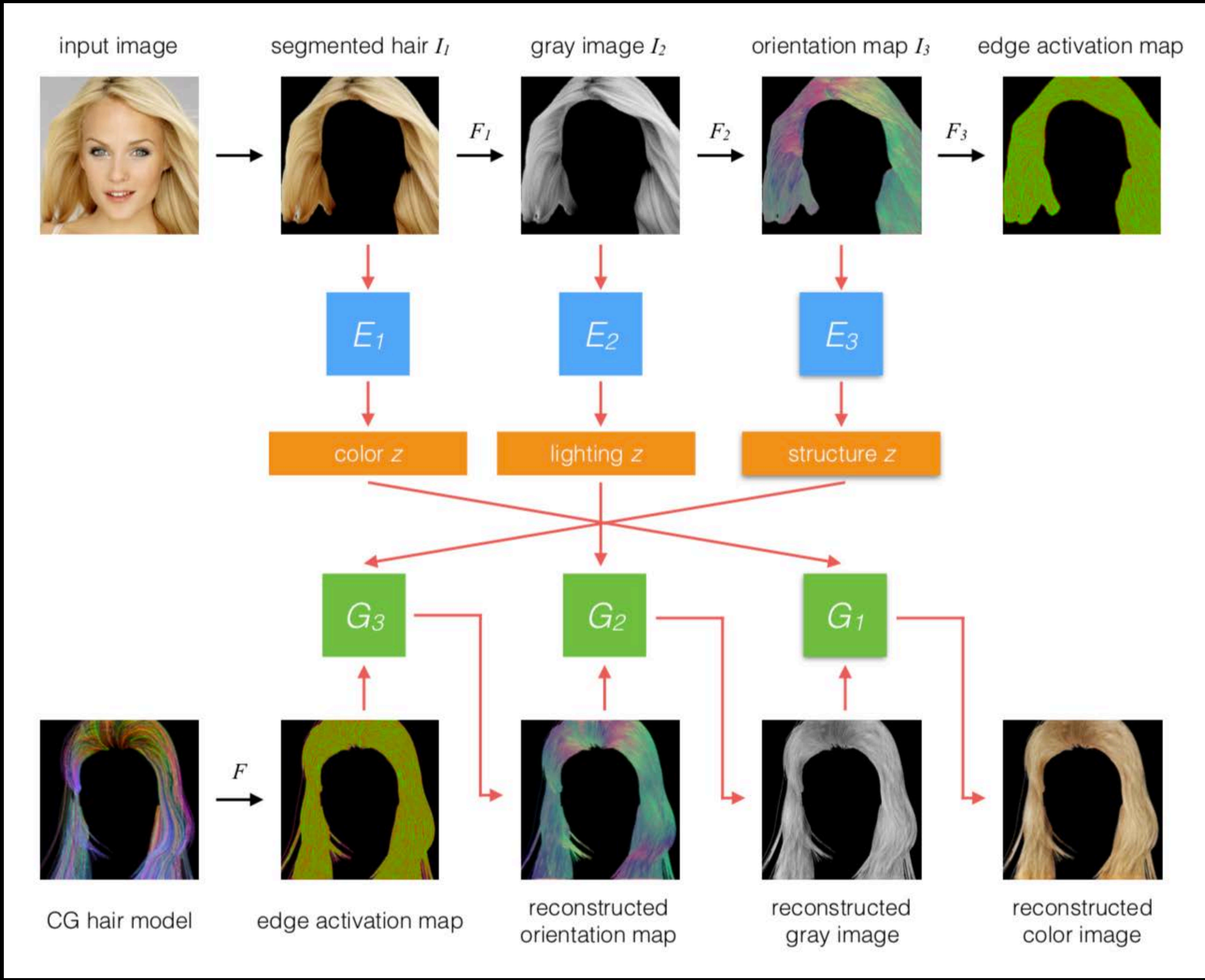
Saito et al. (2018)

Deep Learning for Hair Modeling

Saito et al. (2018)

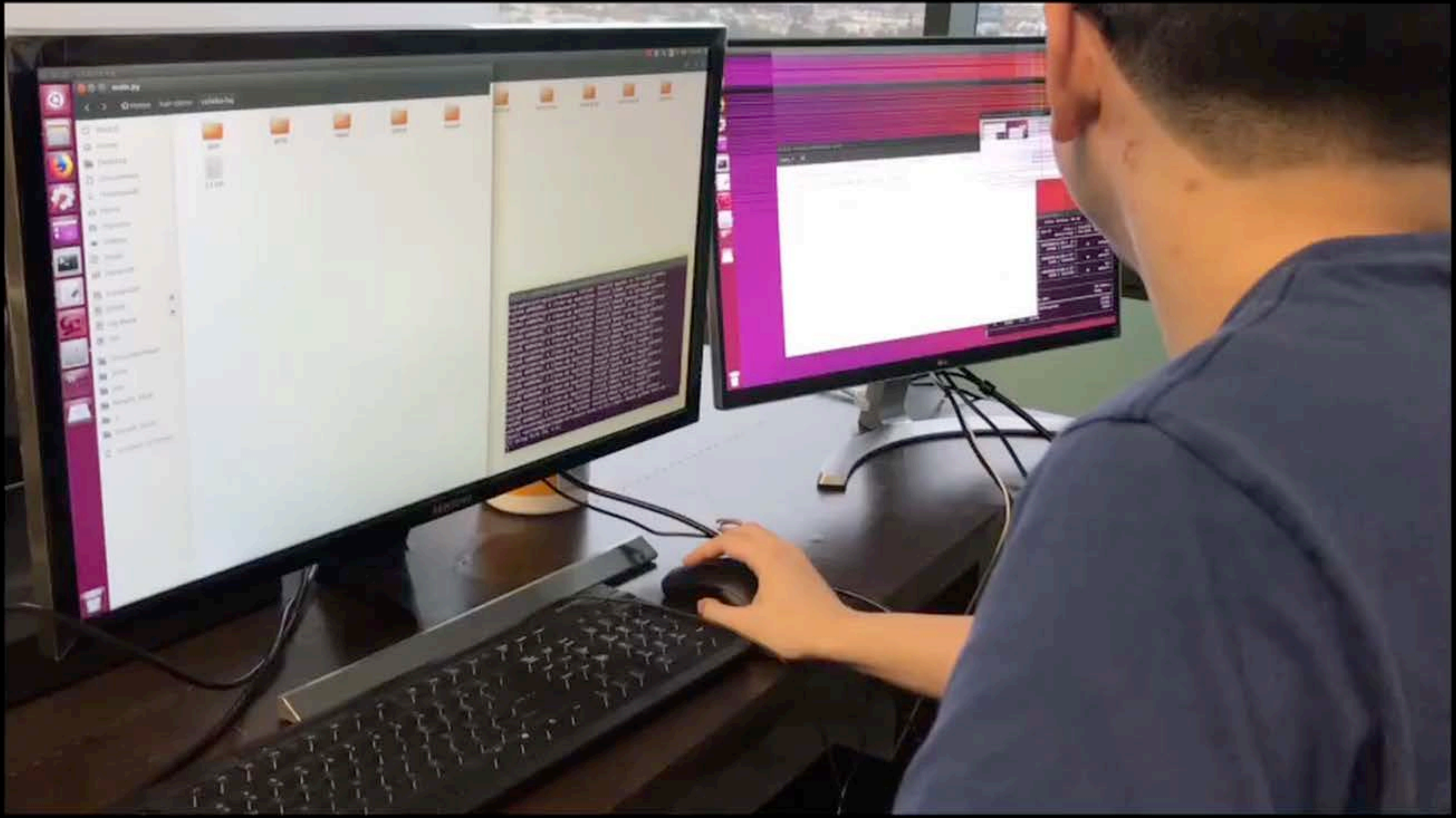
Hair Rendering


Wei et al. (2018)



Wei et al. (2018)

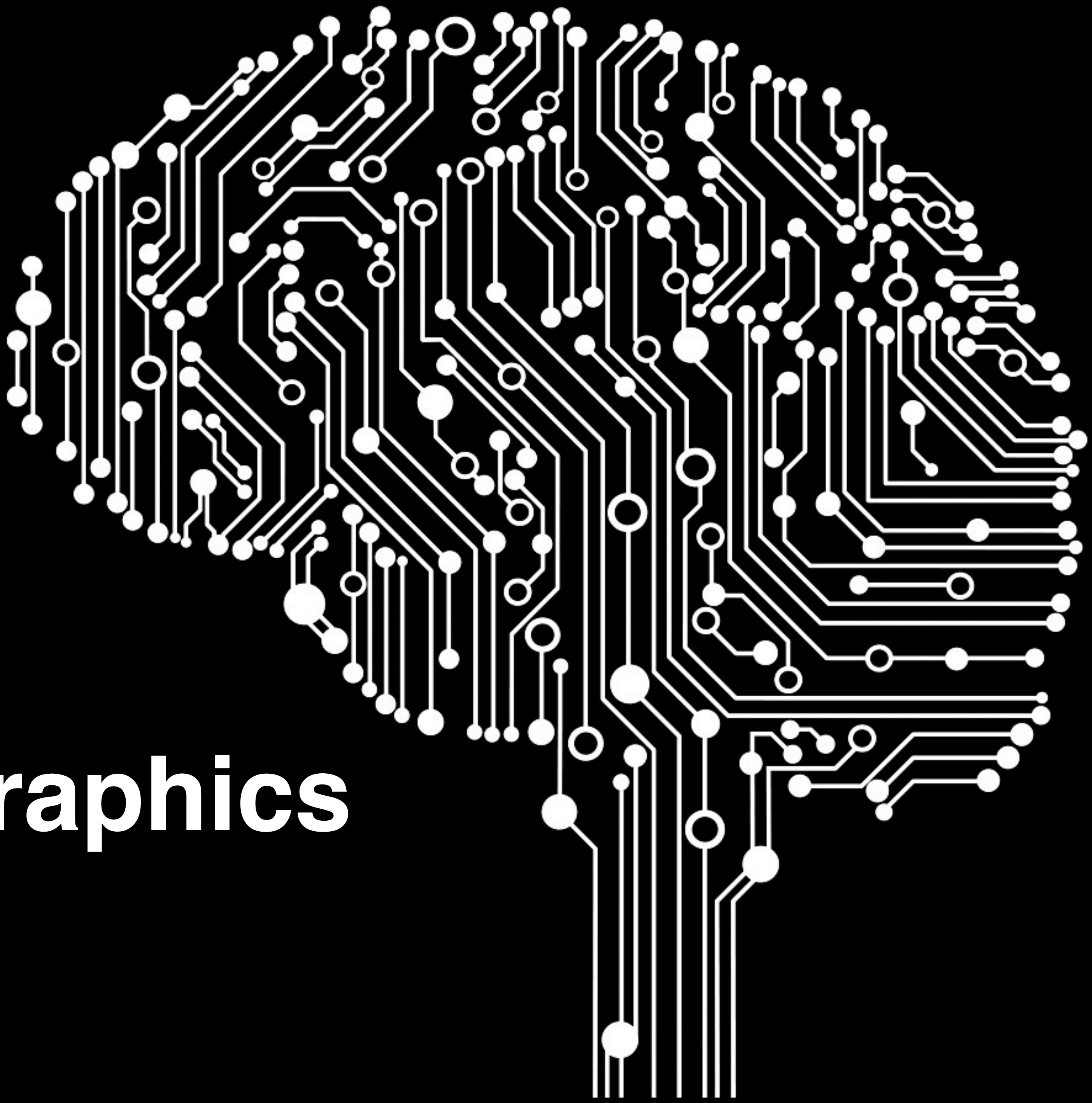
Starting



Wei et al. (2018)

What’s next?

AI-Driven Graphics



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http://cs420.hao-li.com

Thanks!