CS349
Output

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Not that Long Ago

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Quick History of Interaction

- Early Days:
  - No interaction
- Later:
  - Programs may ask for input as they run
  - Example: typical installer script
- Current: Graphical User Interfaces
  - More than just text!
  - High-resolution display; pointer, keyboard

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Quick History of Interaction

- One reason interaction design has changed so much is tied up in the evolution of interaction
  - Early days
    - Computers used by experts
    - Very limited behavious
  - Later
    - People were trained to use computers
    - Specific tasks
  - Now
    - Everyone uses computers with limited training
    - And computers do much more

Temporal vs. Spacial

- Temporal vs. Spacial
  - Temporal: being spread out in time
  - Spacial: being spread out in space

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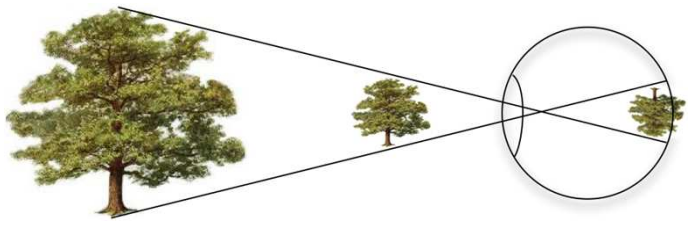
Human Elements of Graphical Output

- Psychophysics: "out there" vs. "in here"
- Eyes



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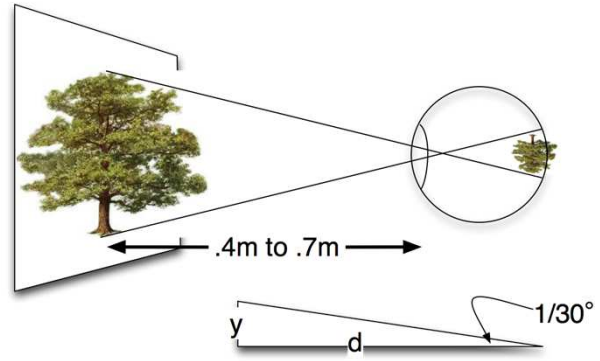
Resolution



Yields desired dot pitch of just under 0.25mm, which is what modern monitors typically have

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iPhone's 'Retina' Display

- Just a marketing name Apple came up with
- Justified?
  - 2" x 3" display with 640x960 resolution
  - About 326dpi
  - 1 pixel: $\frac{1\text{in}}{326\text{dots}} * \frac{25.4\text{mm}}{1\text{in}} = .078\text{mm}$
- At what distance are the pixels distinguishable? $\frac{.078mm}{d} = \tan\left(\frac{2}{60}\right)$

$$d = \frac{0.78mm}{.00058} = 134mm = 13.4cm \approx 5in$$

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Visual Acuity

- High resolution only applies to about 1% of the photoreceptors in the eye
  - Focus ⇒ moving it to the high-res area of the retina
  - Other 99% of photoreceptors help determine where to focus

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Temporal Issues

- Smoothness
  - Under what conditions does the motion appear smooth?
  - Why does it appear smooth?
  - Hardware implications?
- Attention-grabbing
  - Evolution
  - Web ads
  - Implications for GUIs?

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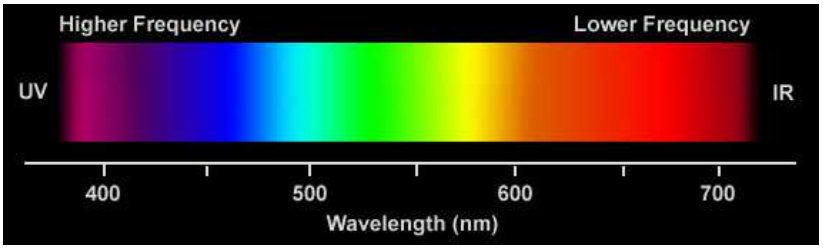
Human Color Vision

- Color
  - Can add to or detract from a user interface
  - Understanding color is important!
  - Influences aesthetics of interface, and ergonomic/human factors issues

Colour

- Three different common colour models
- Additive
  - HSV – used to describe colour
  - RGB – used on displays
- Subtractive
  - CMY/CMYK – common in printing

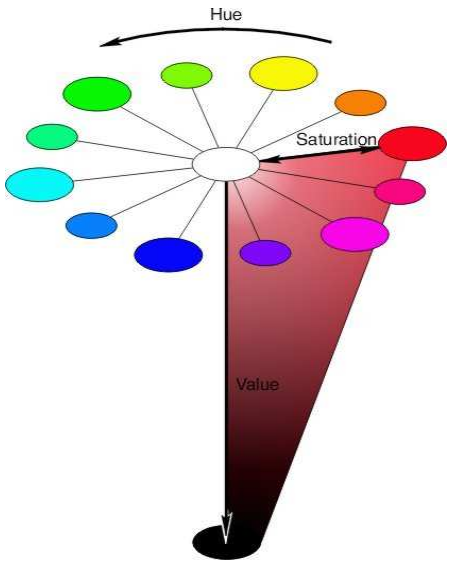
Visible spectrum



HSV Color model

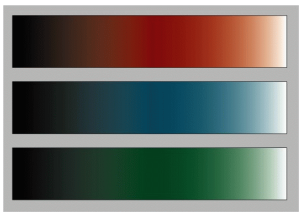
- Described “real world” colour
- Hue
  - Wavelength of light
  - Determines color
- Saturation
  - How much hue: e.g. red vs. pink
- Value
  - Brightness: i.e. how much light is reflected
    - Hues vary naturally
- Frequent confusion between saturation and value

Color model



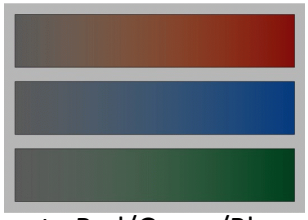
Value vs. Saturation

Reflecting less to more light



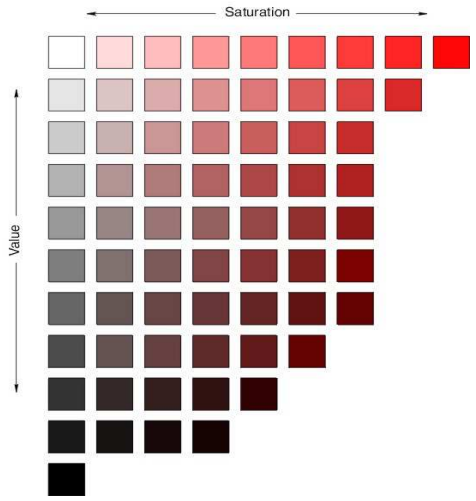
Black to white
Fixed saturation, more to less value

Containing less to more hue



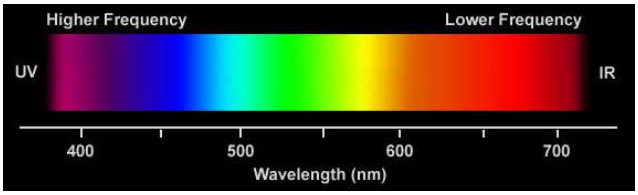
Gray to Red/Green/Blue
Fixed value, changing saturation

Value vs Saturation: Another View



Colour in the Real World

- Colour is Hue + Saturation + Value
- So orange is around 600 – 620 nm, and the same orange wavelength can be brighter or darker and can have more or less orange in it.

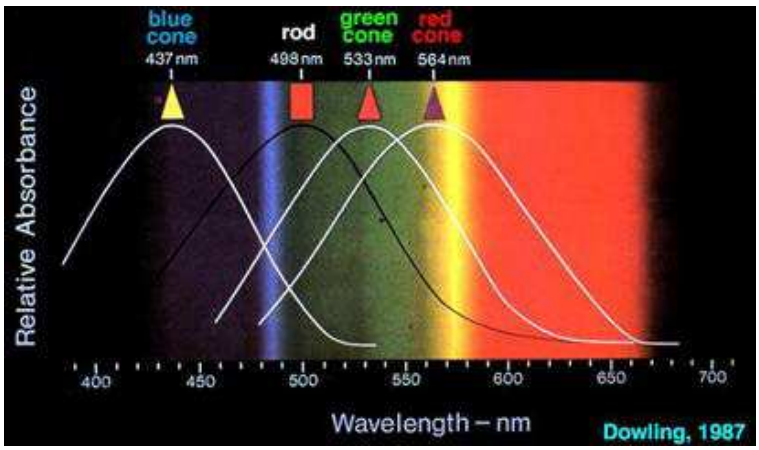


- Next question:
  - How is colour created on the computer display?

Perceiving Colour

- To understand computer display colour and why it works, need to understand human eye
- Two different sensors in human eye that analyze light
  - Cones
  - Rods
- Cones are used to perceive colour
- Rods distinguish light from dark

Color sensitivity



From Fleet's vision slides

Perceiving color via cones

- Different cones sensitive to different pigments
  - 3 primary cones
    - Blue, green, and "red" (yellow)
    - Variations in stimulation lead to sensing of different colors
    - "Red" cones are very common
      - ~ 2/3
      - Clustered in centre of eye
    - Blue very rare
      - ~ 5%
  - Harder to notice blues than reds and no blues in center
    - Implications?
      - Disappearance of blue objects you fixate on

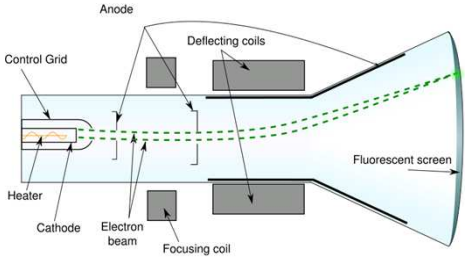
RGB colour

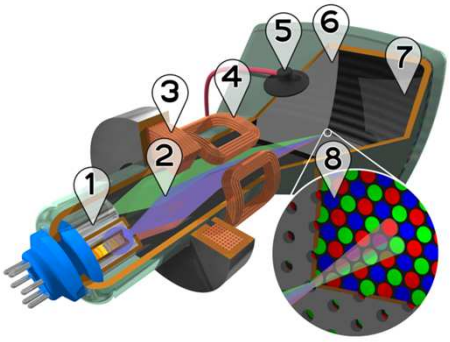
- Vary amounts (intensity) of red green and blue sub-pixels
  - Varies excitation of cones
- 16 versus 24 versus 32 bit colour
  - 16 = 5 red, 5 blue, 6 green
    - 2^5 = 32 values for red and blue, 64 for green
    - 65536 colours
  - 32 = 24 bit colour + 8 bit alpha channel
    - 16 777 216 distinct colours

Graphic Display Technology

- Various display hardwares
  - Colours all based on RGB
  - How colours/pixels rendered differs
- Common idea
  - Each pixel is actually three sub-pixels, a red, green and blue pixel
  - Pack the subpixels very close together so they seem to be colocated
  - Recall: What is the spatial acuity of vision?
- Graphical Displays
  - CRT monitors
  - LCD monitors
  - Plasma displays

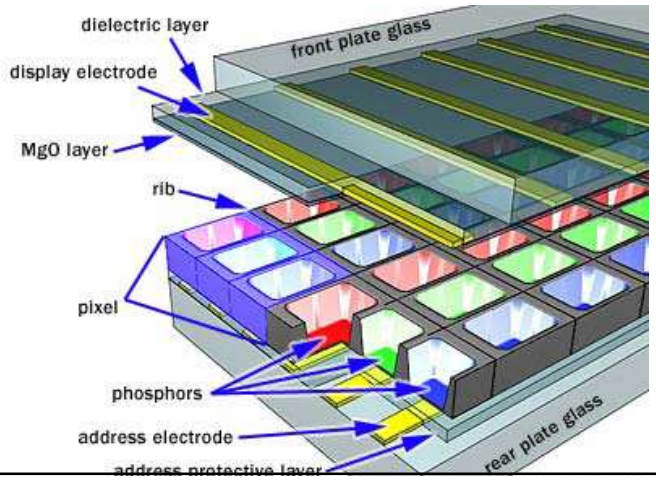
CRT Monitors





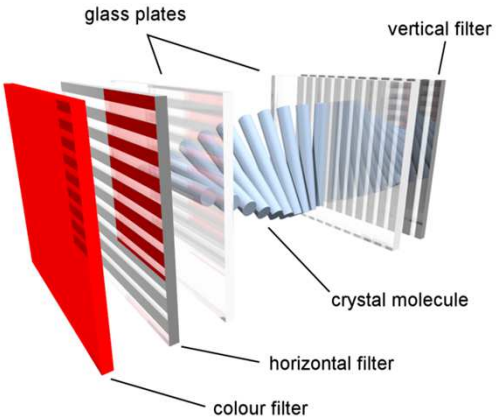
Pictures from Wikipedia

Plasma displays

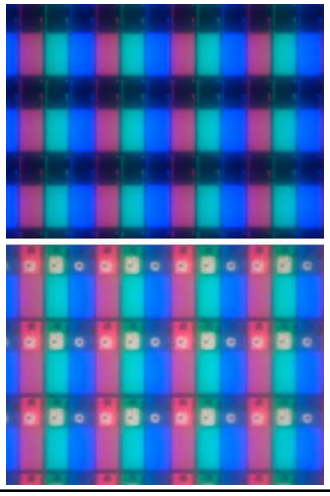


UIUC, 1964
Bitizer, Slottow, **Willson**

LCD Displays



wikipedia



Reflective versus backlit

Displays: LEDs

- Typically used as backlights in LCD displays to increase energy efficiency.
- OLED (Organic LED) displays are used in some portable devices. Larger sizes have been demonstrated.
- Energy efficiency is the primary benefit, and this is a big deal in portable devices

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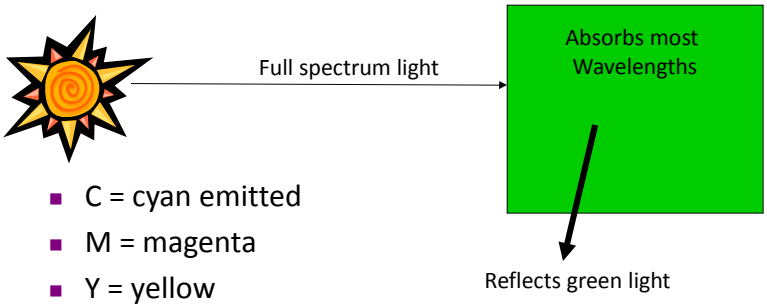
Colour on Printers

- Printers are bit different
- Don't emit light; instead, printed page reflects light
- As a result, colour model is different

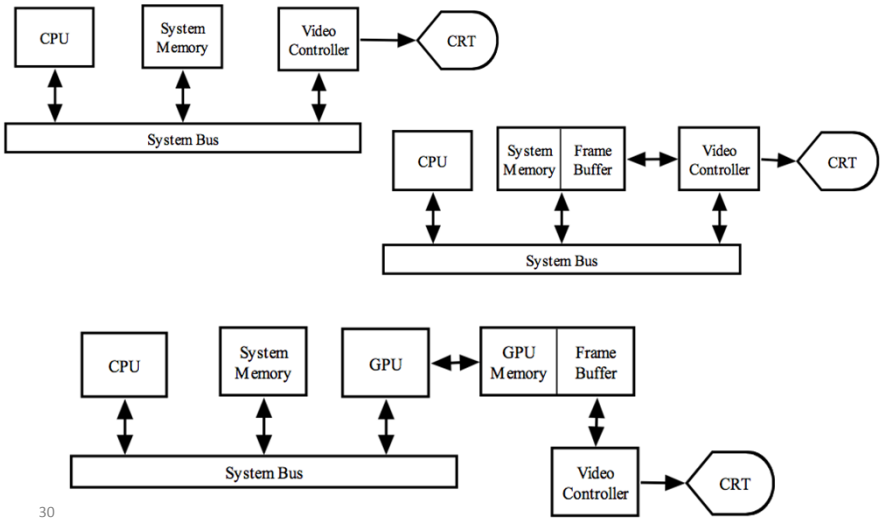
CMY/CMYK

- Why is something green?
  - It emits green light
- What does it mean to reflect green light?



- C = cyan emitted
- M = magenta
- Y = yellow
- Others absorbed

Getting Info to the Display



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Abstracting the Display

- Eventually want multiple overlapping windows.
  - But not yet...
  - Focus first on a single surface to draw on: a *canvas*

- Fundamental operation: writePixel(x, y, color)
- Other operations to change pixels:
  - ✦ draw line
  - ✦ draw rectangle
  - ✦ draw oval
  - ✦ ...

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Summary

- Properties of our eyes and brains influence hardware and software
- Output hardware has evolved
  - CRT
  - LCD
  - LED
  - ...
- As we put more stuff on the screen, we've needed to adjust our architectures
- Abstract the screen with writePixel(x, y)

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