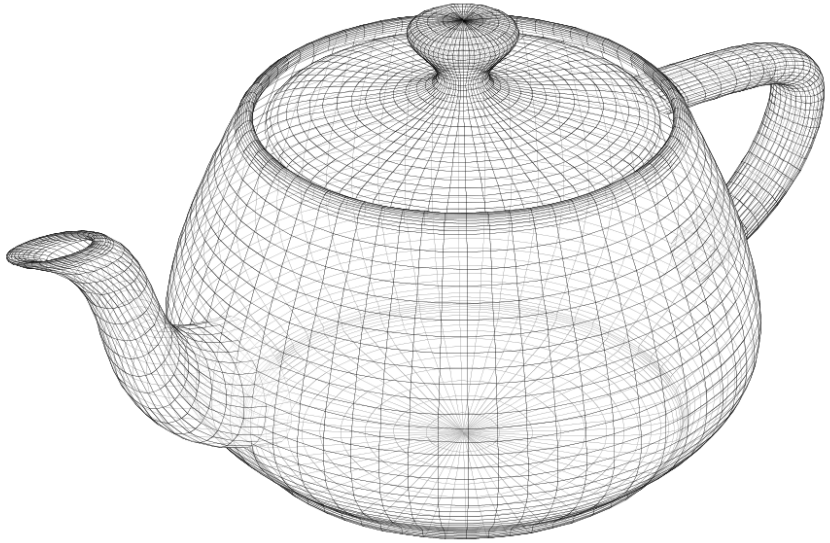

Digital Images

Display-Derived Color Spaces

CS 418: Interactive Computer Graphics

Professor Eric Shaffer

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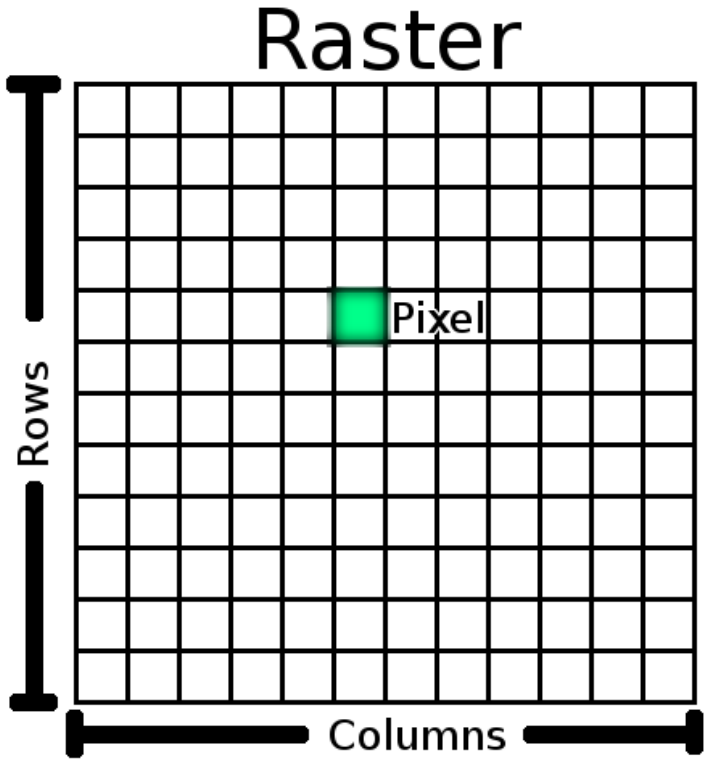
Digital Images

Most modern digital displays rely on a *raster* of *pixels*



A *raster* is grid of addressable image elements called pixels

A *pixel* is the smallest controllable element of a digital image

"pixel" is short for "picture element"

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Digital Display Technology

Most modern digital displays are either LCD or OLED displays

There are a lot of technologies and variations…we won't go in depth

First: what are those acronyms?

LCD: Liquid Crystal Display, transmissive using a light-emitting diode (LED) backlight

OLED: Organic Light Emitting Diode, uses emissive organic film to generate light

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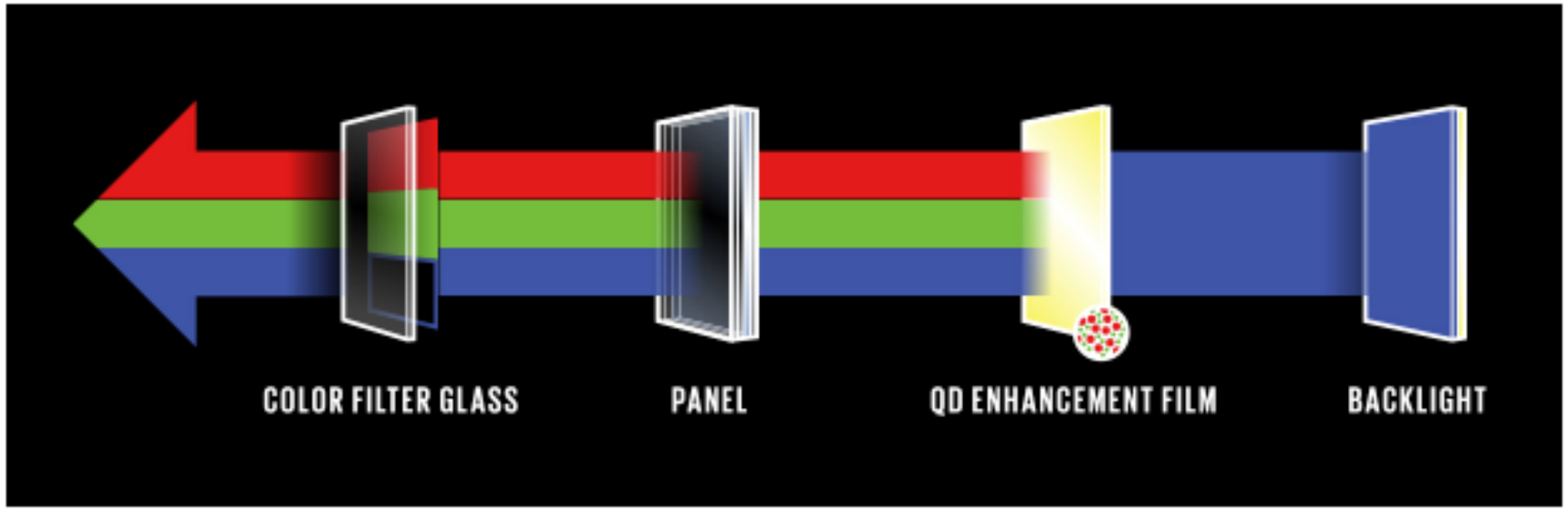
LCD-LED Displays



- A backing array of LEDs generates blue light
- Light is transmitted through a photo-emissive film to generate desired wavelengths of light
- Here, we see that each pixel can be thought of as having Red, Green, and Blue subpixels

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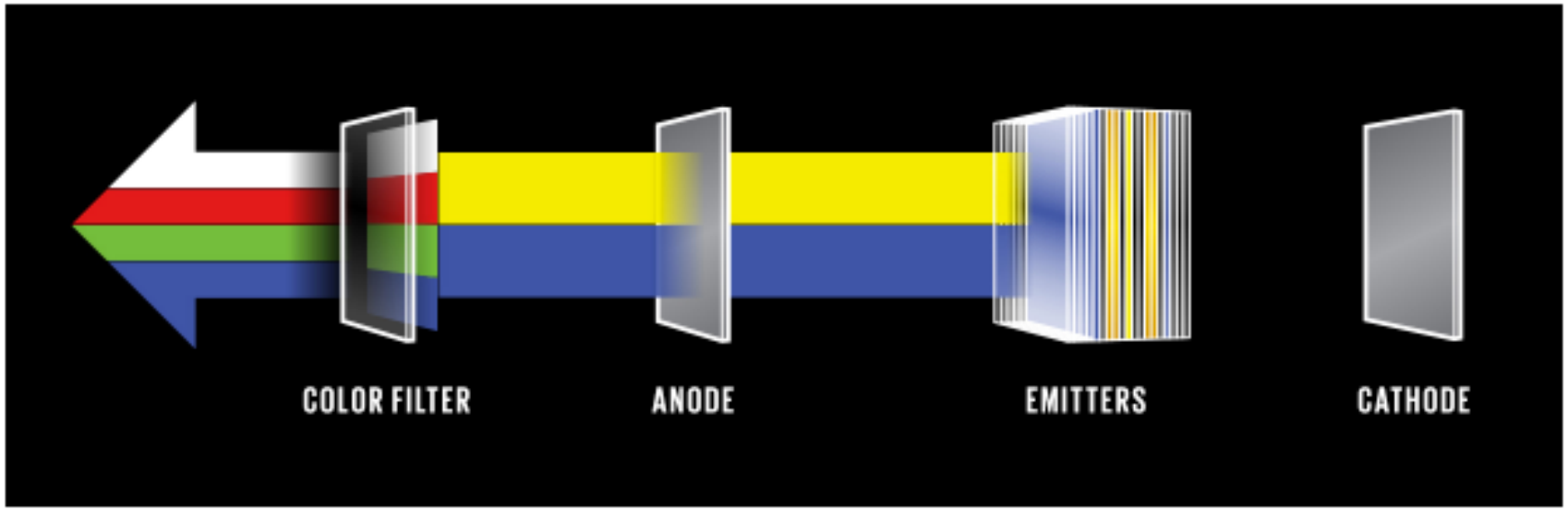
OLED Displays



- Uses mix of blue and orange-yellow OLED emitters to create white light
- Light passes through filters to create red, green and blue sub-pixels
- A fourth subpixel lets white light through

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OLED and LCD-LED Comparison

OLED Advantages

- Deep black levels
- Excellent viewing angle
- Fast refresh
- Can potentially be manufactured on flexible substrates

LCD-LED Advantages

- Cheaper!
- More energy efficient

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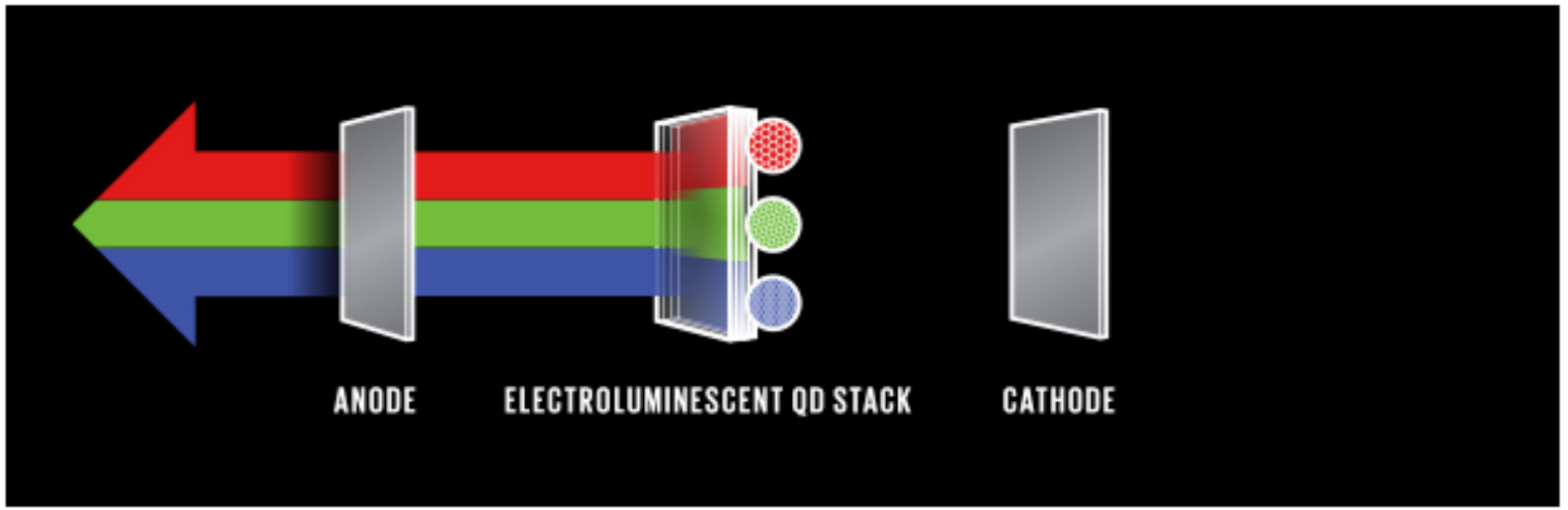
The Future?

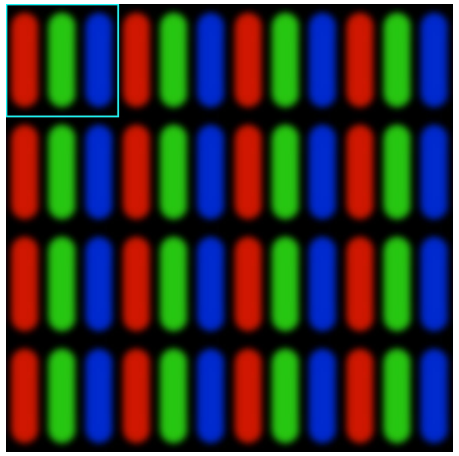
Electro-Emissive Quantum Dot Display

- No viewing angle issue
- Perfect black level
- Low cost
- Flexible substrate
- Fast refresh rate

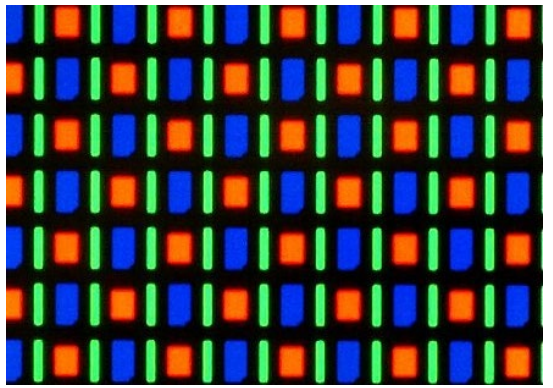


Subpixels

We can generalize that each pixel consists of red, green, and blue subpixels



In practice, different subpixel geometries are used by different displays
PenTile displays mimic the sensitivity of the human eye



"PenTile was invented by Candice H. Brown Elliott, for which she was awarded the Society for Information Display's Otto Schade Prize in 2014."
- Wikipedia

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RGB Color Space

- Emissive displays typically use an RGB space to specify colors
  - R,G, and B are called ***primaries***
  - Each corresponds to a specific wavelength of light
- This means a pixel color is usually specified by a tuple of 3 numbers (R,G,B)
- Each of the R, G and B values are referred to as a ***color channel***
- The value of a channel is referred as the ***intensity***
- Typically, each channel value will be a floating point number in [0.0, 1.0]
  - 0.0 means no light
  - 1.0 means full intensity

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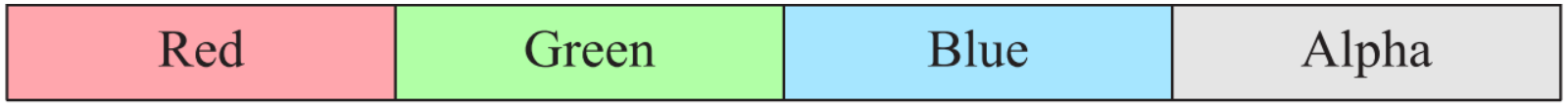
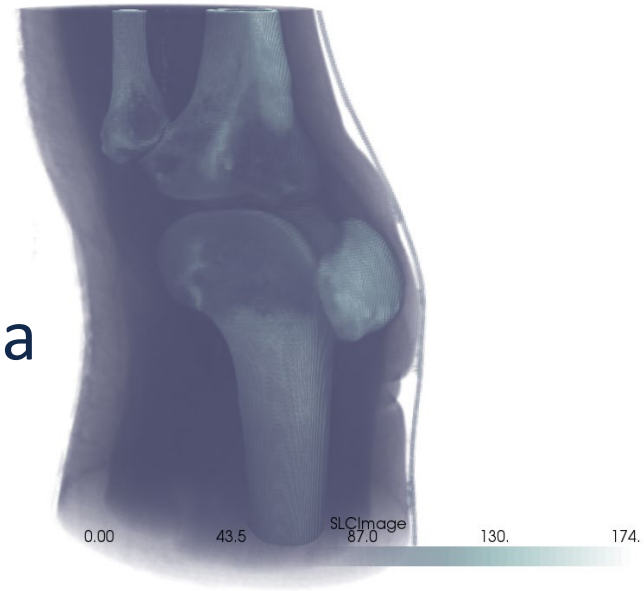
Alpha Channel





- Some color representations include a fourth channel: alpha
  - RGBA representation
- Alpha represents opacity
  - 1.0 is opaque
  - 0.0 is transparent
- These are referred to as RGBA colors
- Useful for simulating semi-transparent surfaces and compositing
  - e.g. visualizing MRI data

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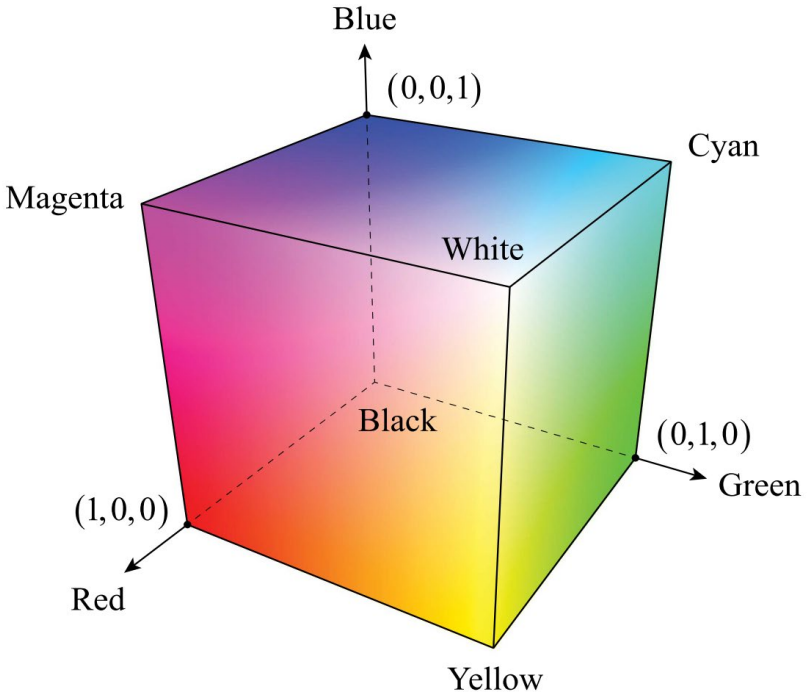
Operations on Colors



- We can add and subtract RGB triples component-wise
  - Like turning on multiple lights and turning off lights
  - Values add/subtract linearly, results clamped to [0,1]

- The set of all linear combinations of forms the space of all colors we can create
- To simulate reflection, we can multiply two RGB triples
  - e.g. reflecting white light off a blue surface (1,1,1)x(0,0,1)=(0,0,1)
  - The surface absorbs non-blue wavelengths

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