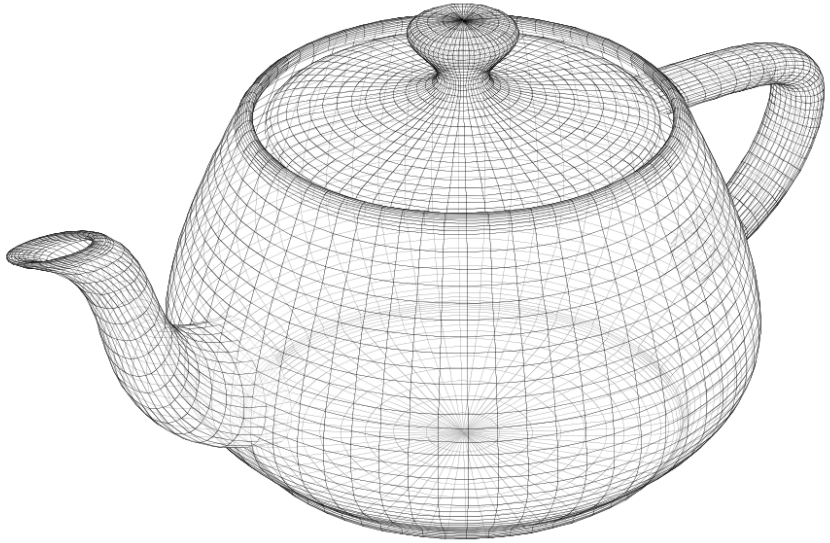
Gamma Correction



Interactive Computer Graphics

Professor Eric Shaffer

ILLINOIS

Gamma Correction

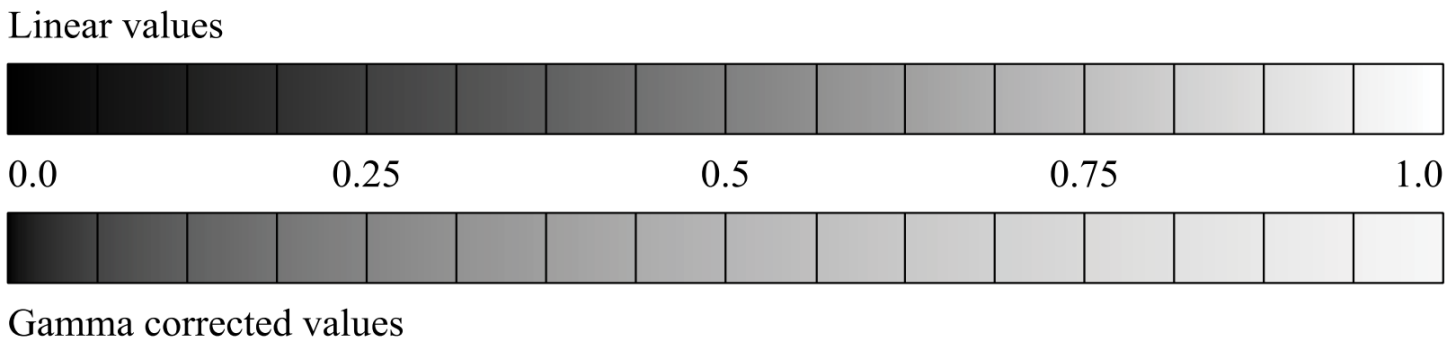
In the days of CRT displays, due to the nature of the technology,

- the brightness of a subpixel was non-linear function of the input brightness
- $V_{display} = V_{signal}^{\gamma}$
- γ varied by display, but 2.2 was a typical value

Color channels have intensity values in the range [0,1]

This meant displayed colors were darker than the input color

This can be adjusted by ***gamma correction***…using inputs of $V_{signal}^{1/\gamma}$



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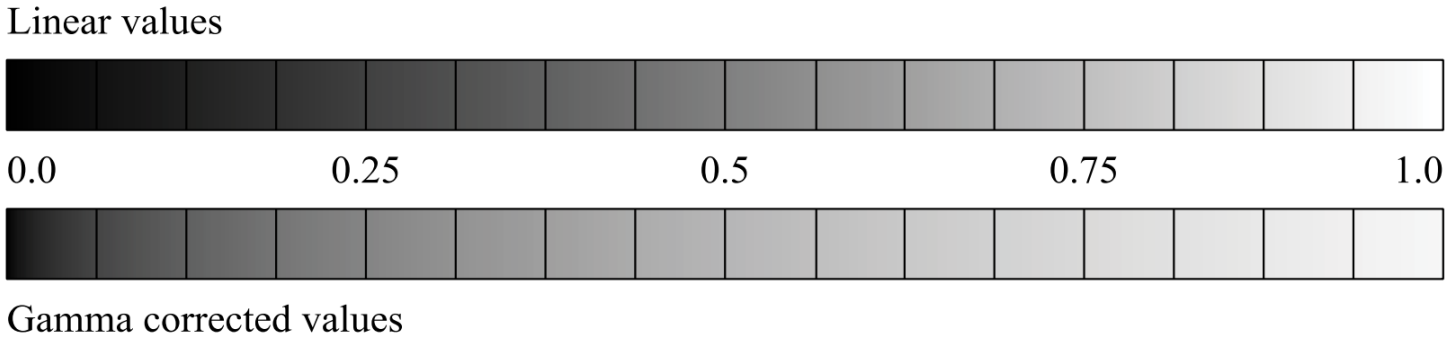
Gamma Correction

- It’s not clear if the CRT gamma was an unavoidable feature
  - Possibly a design choice
  - Human vision is more sensitive to lower intensity light
  - Human vision is more able to differentiate darker shades
- LCD-LEDs do not have to use gamma
  - Most do…most use a gamma of 2.2…but not all
  - Gamma values for different displays will vary
- The sRGB standard uses gamma
  - Meaning pixels in a sRGB image file have had gamma correction applied

Gamma Correction

1) When we create an image using software, the pixels start as *linear values*
2) Before pixels are stored in a file or displayed we can gamma correct them

   Store inputs of $V_{signal}^{1/\gamma}$
3) When displayed on a screen, the pixels should then appear as linear again



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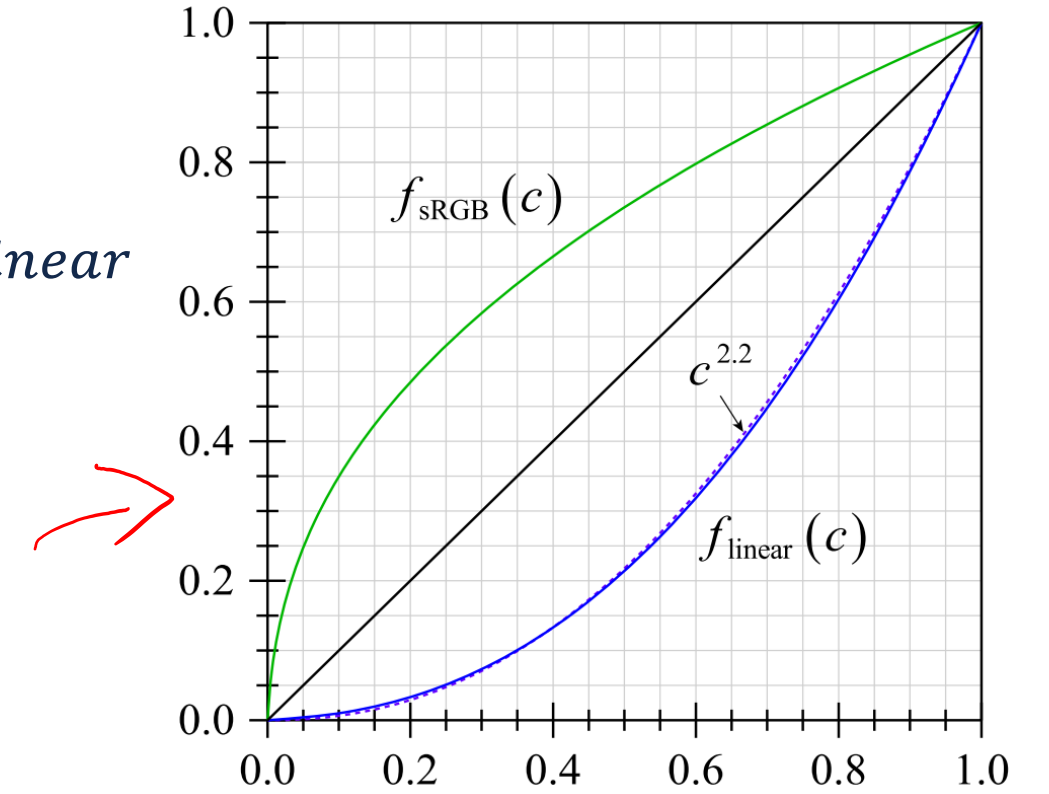
Gamma Correction in sRGB

An image stored in the sRGB format has gamma-corrected pixels

$$f_{\text{sRGB}}(c) = \begin{cases} 12.92c, & \text{if } c \le 0.0031308; \\ 1.055c^{1/2.4} - 0.055, & \text{if } c > 0.0031308. \end{cases}$$

To decode an sRGB color you need to apply f_{linear}

$$f_{\text{linear}}(c) = \begin{cases} \dfrac{c}{12.92}, & \text{if } c \le 0.04045; \\ \left(\dfrac{c+0.055}{1.055}\right)^{2.4}, & \text{if } c > 0.04045. \end{cases}$$



Working with Gamma

You usually do not need to gamma correct an image you create

When saving as an image, the library code will apply gamma correction

- e.g. libpng will encode the image data according to the sRGB standard
- …although you can specify an alternate gamma if you wish

When displaying an image you create in a browser…it's not clear what to do

- e.g. WebGL standard does not specify that colors should be gamma-corrected
- Gamma behavior could vary by browser and OS and GPU….
- Could create a control on the app to enable/adjust gamma manually

Gamma and Visualization

If you are using stored images that you will process computationally

- Need to remove the gamma correction before working with the pixels
- Most image processing operations work with linear colors
- Again, library code can likely be used to read image and linearize colors

Gamma Compression

So…why is gamma still used by modern displays?

- Legacy images encoded with gamma correction…maybe?

Also useful when downsampling images from higher to lower bit-depth

- Human vision has trouble differentiating bright intensities
- Implies that we should allocate more precision to lower intensities when downsampling

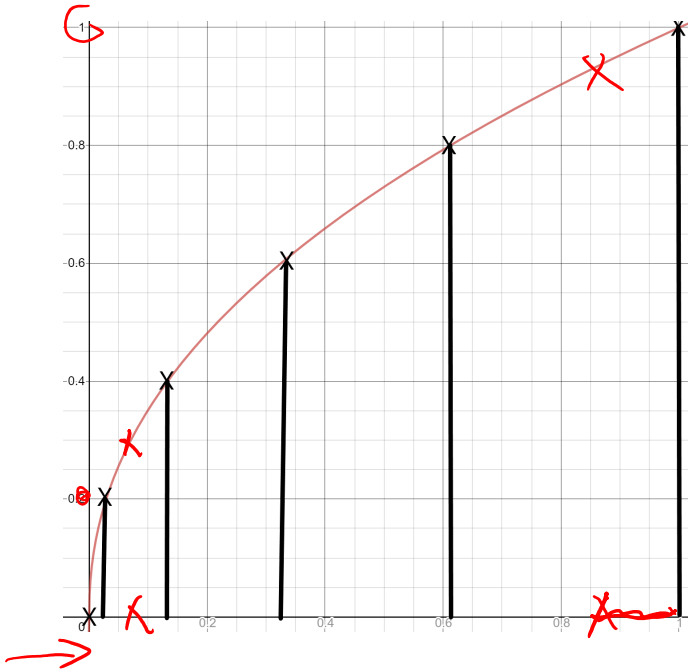
Gamma Compression: Example

Suppose we are downsampling

- The target space can represent only 6 values: 0, 0.2, 0.4, 0.6, 0.8, 1.0
- Procedure is
  - gamma correct raw value x
  - then round to closest value of the 6 we can represent

- in the graph on the right, raw values are on the x axis
- the y axis shows the gamma corrected values
- gamma corrected values get rounded to a representative

…we can drop lines from representatives down to the x axis and see that we are more densely sampling darker values



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