On Gamma correction

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**Problem**: displays produce light intensity $L$ in a non-linear manner:

$$L \approx v^\gamma,$$

where $v$ is the coded intensity value and $\gamma$ is a display-dependent constant.

If $RGB$-image, then all intensity functions have their own $\gamma$ values:

$$L(R) \approx v(R)^{\gamma_R}$$
$$L(G) \approx v(G)^{\gamma_G}$$
$$L(B) \approx v(B)^{\gamma_B}$$
⇒ cameras do already assume some $\gamma$-values and code $\gamma$-corrected intensity values:

$$v(X) = I(X)^{1/\gamma_X}$$

Now the display represents the colours correctly, if the $\gamma$-values just are the same:

$$L(X) = v(X)^{\gamma_X} = (I(X)^{1/\gamma_X})^{\gamma_X} = I(X)$$
Other colour spaces

- **XYZ**: only \( Y \) (luminosity) is affected
- **Lab** and **Luv**: only \( L \) (lightness) is affected
- **HSI**: only \( I \) (intensity) is affected

Gray-scale images: just one \( \gamma \) (brightness)

Typical \( \gamma \)-values

- most CRTs (cathode ray tubes): \( \gamma \in [2.0, 2.4] \)
- MacIntosh: \( \gamma \approx 1.5 \)
- SGI: \( \gamma \approx 1.3 \)

E.g. if \( \gamma = 2.2 \) (PC monitor), then the camera encodes the intensity by \( v = I^{1/2.2} \approx I^{0.45} \).
**When \( \gamma \) is problem?**

- often the used \( \gamma \)-value is unknown and varies between devices

- the same colour has different codes, when the lightning varies → has intensity, chromacity or both changed?

- often the image processing algorithms need the true colours

E.g. how to find the same hue of wood or stone, when the images are taken under different lightning conditions?

⇒ we should eliminate \( \gamma \)-correction!
Eliminating $\gamma$-correction

Easy, if $\gamma$-values are known!
Otherwise:

- empirical estimation using known reflectance and reference light
- mathematically in the log-space ($\log R$, $\log G$, $\log B$):
  1. calculate the standard deviation of $\log X$ values over all pixels
  2. divide the $X$-values by $\text{stdev}(\log X)$
  (Reason: $\log X^\gamma = \gamma \log X$ [Finlayson and Xu])
- by analyzing higher order statistics – How?? [Farid]
Task

Test the effect of different $\gamma$-values in Linux! You can change the values by command `xgamma`. `xgamma -gamma n` changes all $\gamma$-values to the positive integer $n$. If you want to change $\gamma$-values for R-, G- and B components separately, use three options: `xgamma -rgamma n1 -bgamma n2 -bgamma n3`, where $n1$, $n2$ and $n3$ are positive integers. You can return the default setting by `xgamma -gamma 1`. (This means that the real $\gamma$-value is scaled such that 1.0 is the default in a PC monitor).

You can also try `coolgamma`-program.
Sources


