IB Paper 8: Photo Editing

Lecture 4: Histograms/Lighting Corrections

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Histograms and Lighting correction: `ph_lightshift`

- This script corrects for lighting and exposure problems in images.
- Do this by adjusting the gain applied to the R,G,B components of each pixel. This avoids any change of colour (hue) while remaining in RGB space.
- We generate a gain map containing values greater than or less than unity. The gain map is the same size as the image.

Lighting correction: Histogram equalisation

- Histogram of a poorly lit image will usually show that some pixel intensities are used much more frequently than others.
- Can reduce lighting problems by creating a mapping of intensities that tends to use all the intensity levels as uniformly as possible. This process is known as Histogram Equalisation.
- For a monochrome image with levels 0 to 255, suppose we map level k to level y_k where

$$y_k = \sum_{i=0}^{k} \frac{255\ n_i}{N} \qquad \text{where} \quad N = \sum_{i=0}^{255} n_i$$

  where n_i is the number of pixels in level i. The histogram of the new levels will be approximately uniform.
- Note: for **colour** images, calculate the histogram of the luminance image, obtain the n_i and then scale R,G,B components of a pixel by y_k / k, where k is the luminance of the pixel. This preserves the hue and saturation.

Lighting correction: Gamma correction

- Histogram equalisation is often very effective – see Genoa image. However, we tend to lose resolution at levels where there are few pixels and therefore n_i is small (see buildings near the sea).
- Need to enhance dark regions by applying a gain of > 1 but avoid saturating pixels in bright areas. One way of doing this is to use a non-linear mapping:

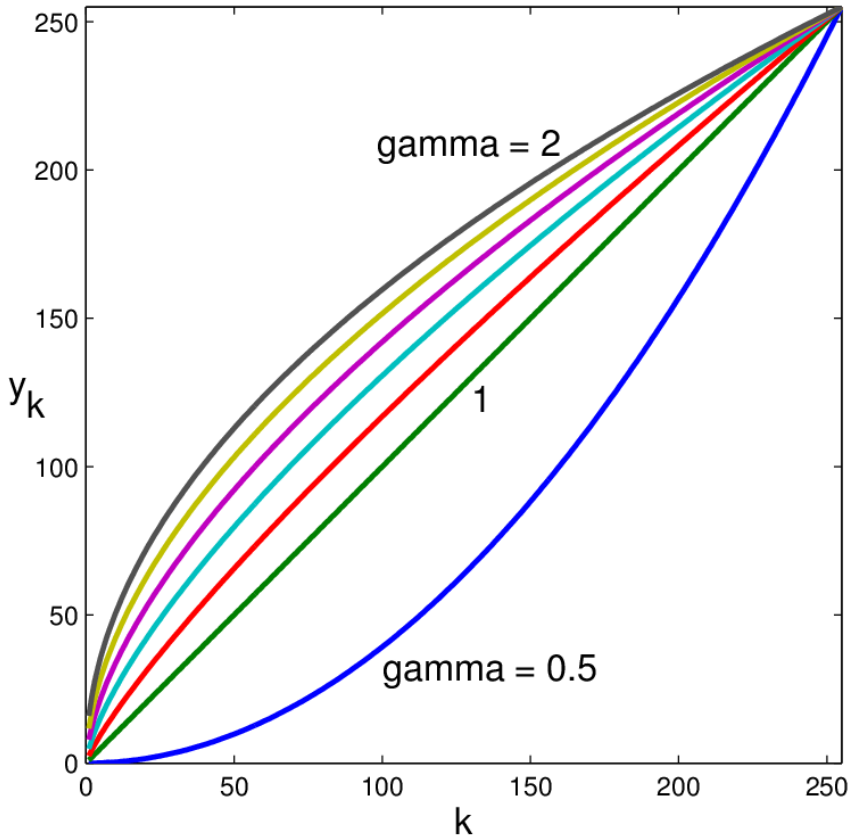
$$y_k = 255\ (k/255)^{1/\gamma}$$

  called a Gamma Correction.

- If $\gamma = 1$, this gives $y_k = k$ (i.e. no correction); if $\gamma > 1$ then low luminance pixels are scaled up while those with higher intensities are left almost unchanged (since $y_{255} = 255$ for any value of γ).

Form of the Gamma Correction

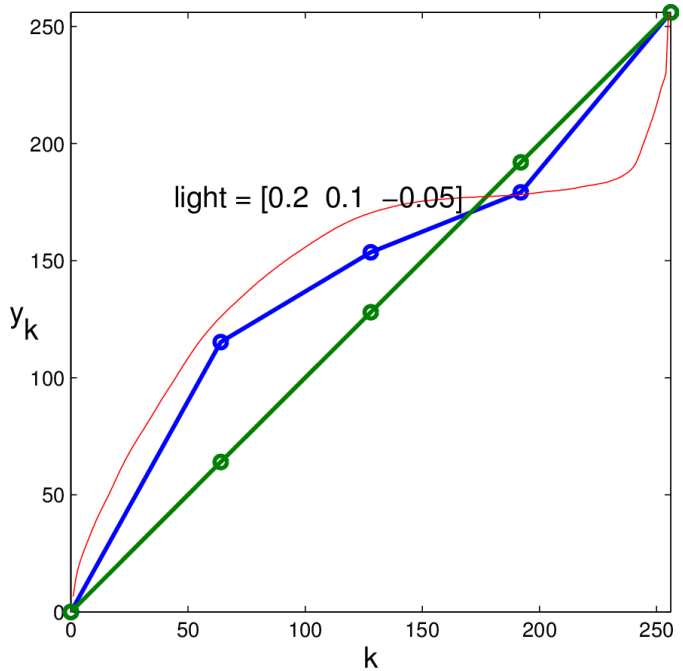
Figure shows plot of y_k against luminance k for $\gamma = 0.5, 1, 1.2, 1.4, 1.6, 1.8, 2$.



As with histogram equalisation, correction is carried out on luminance and R,G,B values are scaled by y_k / k, to correctly preserve colours.

More flexibility: piecewise liner correction

- A more flexible shape can be achieved by specifying a piecewise linear curve in terms of knots. This can deal with shadows and midtones and highlights.
- `light` $= [a, b, c]$, means knots (originally at $y_k = [64, 128, 192]$) move to $[64 + a * 256, 128 + b * 256, 192 + c * 256]$.



Gamma and piecewise linear corrections cont....

- Previous figure plots the histogram equalisation curve (for the genoa image): can see how we can approximate this with a piecewise linear curve, but avoiding low gradient areas which result in loss of contrast.
- Can improve these techniques by a slight blurring of the image before application.
- Blurring can ensure a smooth variation of gain over the image, but can also introduce bright halos around dark objects.
- A Gaussian filter is the most common blurring function. In the lighting function `im_lighting()` it is applied automatically to the luminance image.

The script `ph_lightshift`

Comprises 7 cases selected by `mode`. **lighting** uses a separate switch.

- **Init**: Sets up command box and initialises variables.
- **Slider**: reads the slider values and puts these into the `light(1:3)` or `cgamma` arrays.
- **Edit box**: called when any of the lighting values are entered via the boxes.
- **Reset**: restores default values for the parameters.
- **Hist equal**: performs histogram equalisation on the input image.
- **Close**: closes command box and redisplays images.
- **Lighting**: performs the lighting correction using input values.

The functions im_histeq() and im_lighting()

- im_histeq is a simple function which uses the hist function in Matlab and operates on the luminance Y of a colour image.
- im_lighting is more complex. If there is only a gamma correction, the gain matrix is calculated and applied to the luminance image – then the R,G,B images are scaled.
- If there is a piecewise linear correction: first ensure gradient is positive, then calculate the gradient of each of the 4 sections – apply these linear gains to all pixels lying in their support regions.

Summary

- Have looked at how Photo Editor performs histogram equalisation on colour images.
- Then improved this by applying gamma and piecewise linear corrections.

J. Lasenby (Easter 2016)