IB Paper 8: Photo Editing
Lecture 4: Histograms/Lighting Corrections

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• 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

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

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:

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

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 $\gamma$). 
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 linear 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.

- $\text{light} = [a, b, c]$, means knots (originally at $y_k = [64, 128, 192]$) move to $[64 + a \times 256, 128 + b \times 256, 192 + c \times 256]$. 

![Diagram showing piecewise linear correction with knots and light values]
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 \texttt{light(1:3)} or \texttt{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 \texttt{im\_histeq()} and \texttt{im\_lighting()}

- \texttt{im\_histeq} is a simple function which uses the \texttt{hist} function in Matlab and operates on the luminance $Y$ of a colour image.

- \texttt{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)