Image Processing 2013

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14 lectures + 7 practical sessions

Lectures	Tuesday 10am (every week) – Sportex LT2 **[but no lecture on 5th Feb]**
	Friday 9am (weeks 1,5,8,11 : 11th Jan, 8th Feb, 1st March, 22nd March) – W115
Practicals	Fridays 9am (weeks 2-4,6-7,9-10) – Poynting P9

Assessment:

Exam	80%
Two assessed practicals	10% each

1st assessed practical: issued week 2; due Thursday 14th Feb (week 6)

2nd assessed practical: issued week 7; due Friday 22nd March (week 11)

(For Yr 4, exam will contain "harder" material)

- Digital image representation (monochrome & colour).
- Contrast and perception – look up tables, histograms and point transformations.
- Storage of images – lossless and lossy compression, RLE, Huffman trees
- Image representations – DCT (jpeg), Fourier, Multiresolution expansion, wavelets.
- Image filtration & enhancement.
- Characterising imaging systems – PSF and MTF.
- Binary image operations – thresholding, erode/dilate...
- Spatial transformations – affine transforms, interpolation.
- Image registration and alignment.
- 3D images – projection, surface rendering.
- Methods of tomographic reconstruction.

<u>Books:</u> There are lots of good books on Image Processing at many levels.
Two I have used are

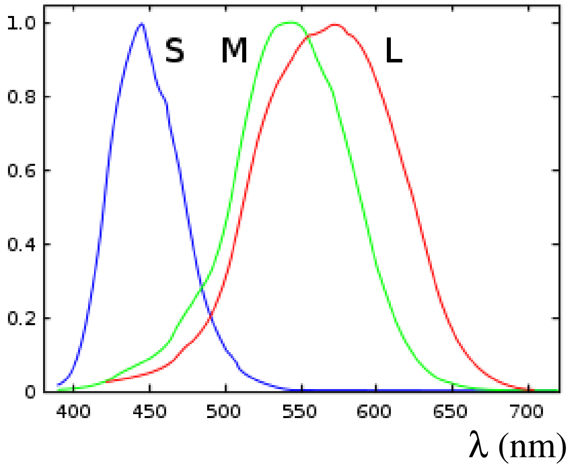
- Digital Image Processing: *Rafael Gonzalez and Richard Woods*, Prentice Hall
- Digital Image Processing – an algorithmic introduction using Java: *Wilhelm Burger and Mark Burge*, Springer

[Neither covers everything in course, for example tomographic reconstruction is missing]

Colour

Human eye contains three types of "cones" which are the colour receptors (short, medium, long) whose sensitivity as a function of wavelength is as below:

Normalised response of receptors in human eye

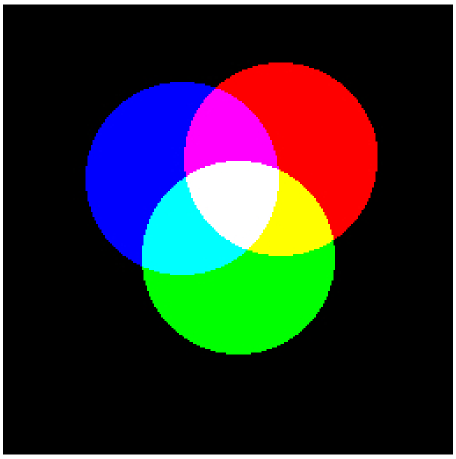


Our perception of colour is purely determined by the relative response of these three receptors.

For example, we cannot distinguish between a continuous spectrum and a line spectrum which gives the same ratio of S/M/L response

Requirement for colour display is to trigger the same S/M/L response as the light from the original "picture"

Display monitor contains three emitters (red, green, blue). By adding these one can generate all required S/M/L responses, so all perceivable colours.



"Primary colours" Red, Green, Blue

In equal parts, R+G+B = White
R+G = Yellow
G+B = Cyan
B+R = Magenta

Note that Magenta (pink) is not part of the spectrum but consists of a mixture of wavelengths from opposite ends of the spectrum

[When painting/printing using ink/die which absorbs particular wavelengths, colours subtract instead of adding, so the primary colours are Yellow, Cyan and Magenta:

Yellow ink absorbs blue light, leaving just red and green (=yellow)
Cyan ink absorbs red light, leaving just green and blue (=cyan)
So yellow ink + cyan ink absorbs both blue and red, leaving just green.
THIS IS NOT OUR CONCERN!]

Mapping image values to brightness (grayscale)

Digital image consists of array of pixel values a_{ij} (integer or real)
On a screen, these are displayed as pixels with brightness b_{ij} , where b is an 8-bit integer, so b has a value in the range 0 (black) to 255 (white)

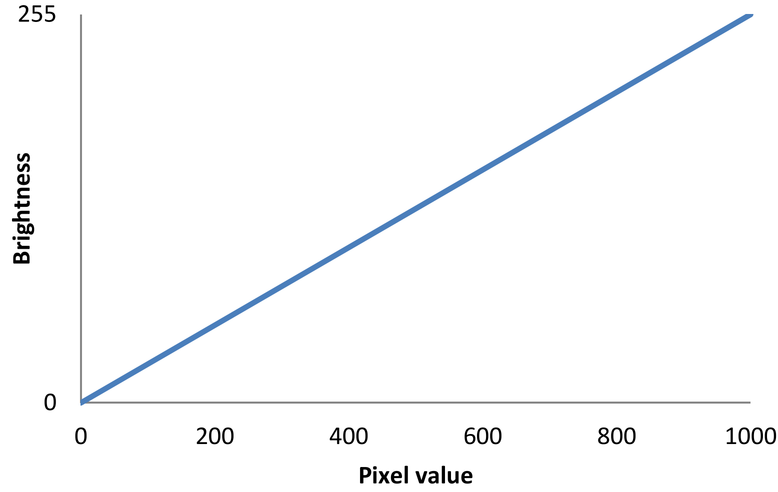
Appearance of the image depends on the mapping used to convert value a to brightness b

This is a monotonically increasing function (if $a_{ij}>a_{km}$ then $b_{ij}\geq b_{km}$)
It's often implemented using a "look up table" so is conventionally referred to as "the LUT"

Examples:

Simple linear mapping of entire range

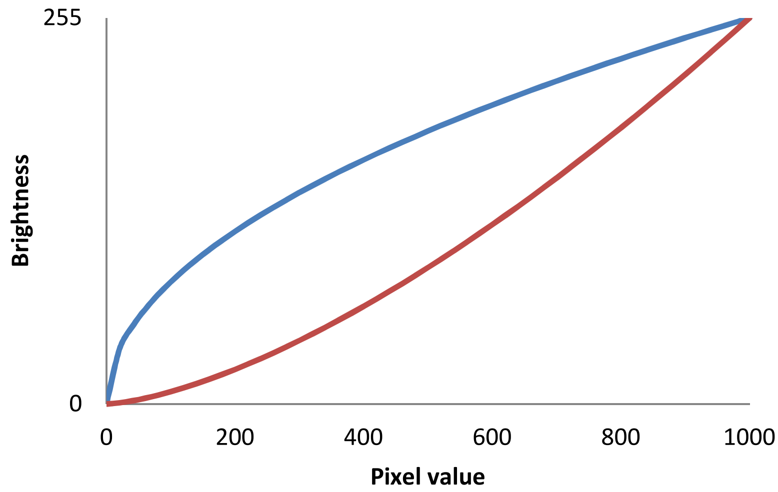
$b=ka$



Power law ("gamma")

$b=ka^{\gamma}$

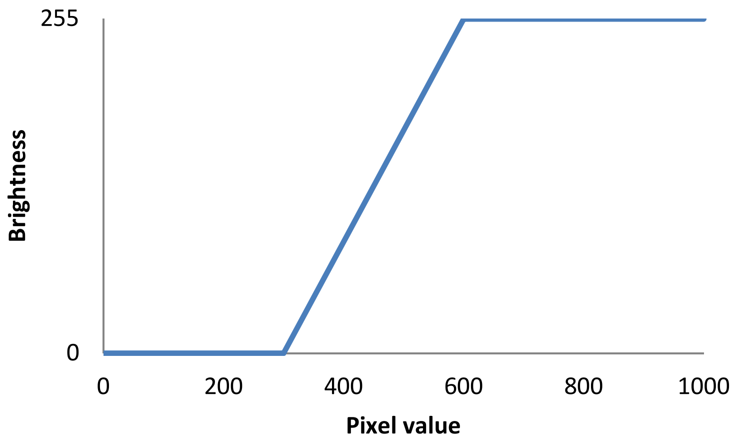
Plot shows γ=0.5 (upper) , γ=1.5 (lower)
Overall effect:
brighten image if $\gamma<1$,
darken image if $\gamma>1$



Windowing:

Use full range of brightnesses
over restricted range of pixel values.

Set pixels below lower threshold to black,
and pixels above upper threshold to white



In choosing a LUT it is often helpful to examine the histogram of pixel values,
which plots the frequency $p(a)$ of value a as a function of a.

In histogram equalization the LUT is chosen to make the histogram of brightness values flat
so that all 256 brightness values are used with the same frequency k.

If $b = f(a)$ then $p(b)db = p(a)da$
so to achieve $p(b) = k$ requires $\frac{db}{da} = \frac{1}{k}p(a)$

As a very crude example, the histogram on the left would require the LUT on the right