6.4 Basics of full-colour image processing

Two categories:

(1) Process each component image individually and form composite processed colour image from the individually processed components

(2) Work with colour pixels directly; colour pixels really are vectors:

$$\mathbf{c}(x,y) = \begin{pmatrix} c_R(x,y) \\ c_G(x,y) \\ c_B(x,y) \end{pmatrix} = \begin{pmatrix} R(x,y) \\ G(x,y) \\ B(x,y) \end{pmatrix}$$

Note: the results of individual colour component processing are not always equivalent to direct processing in colour vector space

Processing is equivalent if:

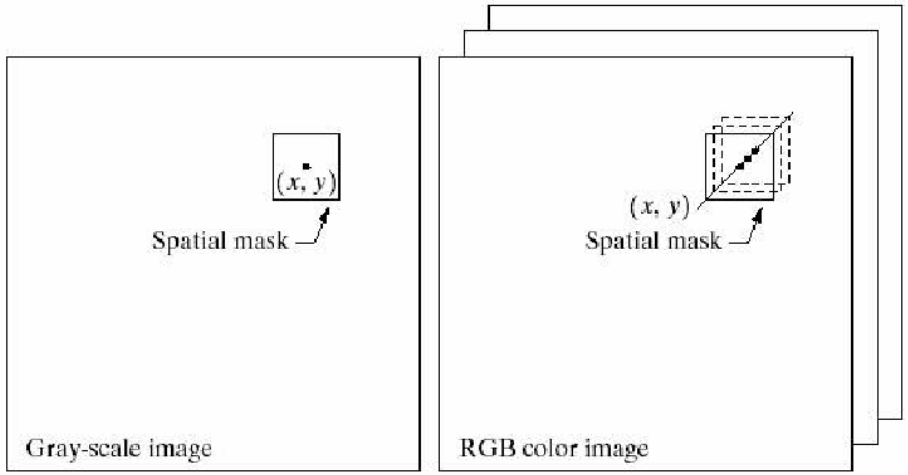
(1) the process is applicable to both scalars and vectors;

(2) the operation on each component of a vector is independent of the other components

Illustration: Neighbourhood averaging

a b

FIGURE 6.29
Spatial masks for gray-scale and RGB color images.



Result for per-colour-component and vector-based processing is equivalent. Why?

6.5 Colour Transformations (Consider single model)

6.5.1 Formulation

Model colour transformations with $g(x,y) = T\,[\,f(x,y)\,]$

Pixel values here are triplets or quartets

Analogous to section 3.2 (gray-level), we now consider

$$s_i = T_i(r_1, r_2, \ldots, r_n),\ \ i = 1, 2, \ldots, n$$

Some operations are better suited to specific models, but cost of converting between representations has to be considered as well! Example follows...

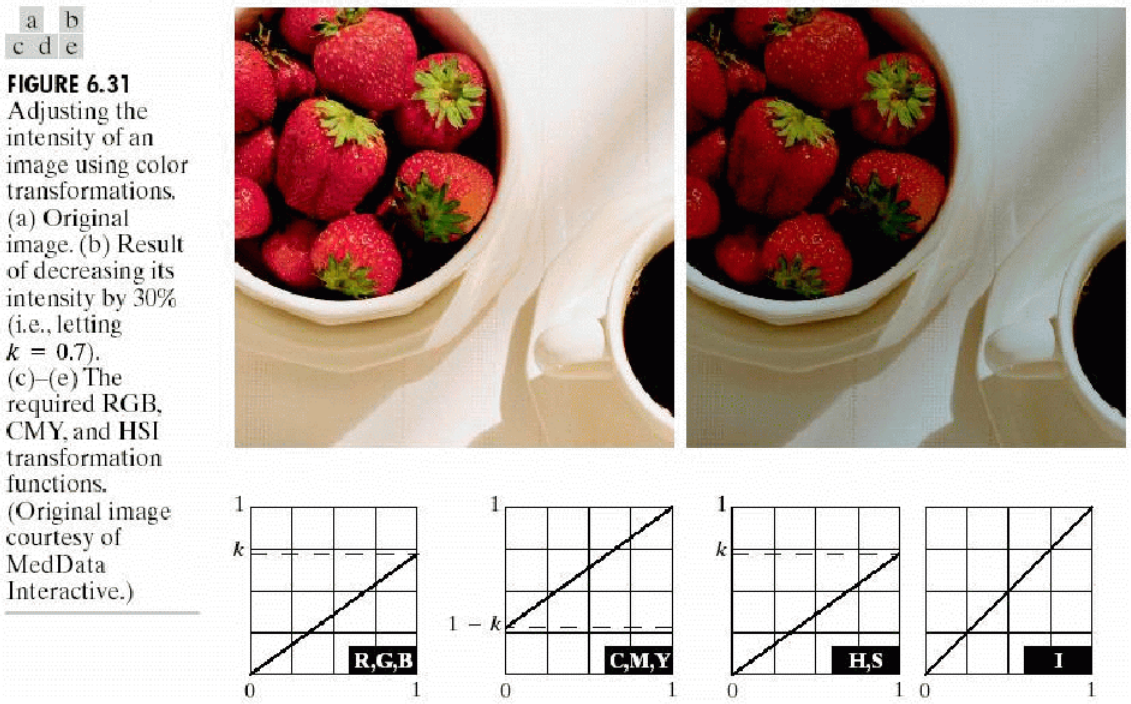
Suppose that we wish to modify the intensity of the image on page 4 using $g(x, y) = kf(x, y)$, where $0 < k < 1$

HSI colour space: $s_1 = r_1$, $s_2 = r_2$, $s_3 = kr_3$

RGB colour space: $s_i = kr_i,\ i = 1, 2, 3$

CMY colour space: $s_i = kr_i + (1 - k),\ i = 1, 2, 3$

Although the HSI transformation involves the fewest number of operations, the computations required to convert an RGB or CMY(K) image to the HSI space more than offsets the advantages of the simpler transformation



6.5.2 Colour complements

Complements: hues opposite one another on colour circle

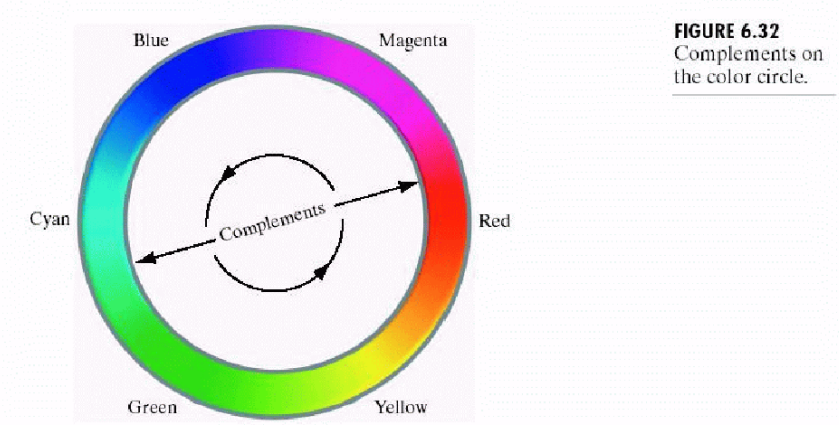
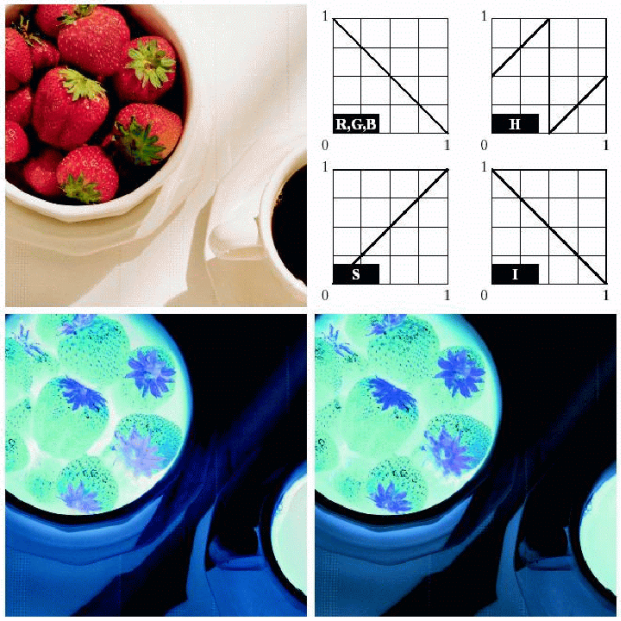


FIGURE 6.32 Complements on the color circle.

Useful for enhancing detail embedded in dark regions



a b
c d

FIGURE 6.33 Color complement transformations. (a) Original image. (b) Complement transformation functions. (c) Complement of (a) based on the RGB mapping functions. (d) An approximation of the RGB complement using HSI transformations.

6.5.3 Colour slicing

Highlight a range of colours to separate objects from their surroundings.

The basic idea is either to

(1) display the colours of interest or
(2) use the region as a mask for further processing

Methods for "slicing" a colour image:

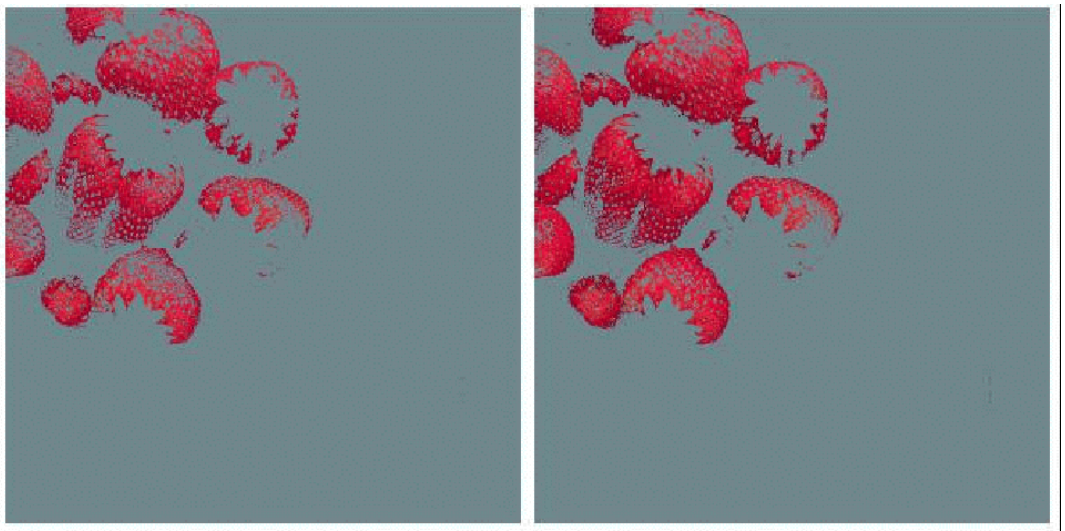
(1) Colours of interest inclosed by cube (hypercube) of width W and centered at $(a_1, a_2, \ldots, a_n)$

$$s_i = \begin{cases} 0.5 & \textbf{if } \left(|r_j - a_j| > \frac{W}{2}\right)_{\textbf{(any } j \in [1,n]\textbf{)}} \\ r_i & \textbf{otherwise} \end{cases}, \; i \in [1, n]$$

(2) Colours of interest inclosed by sphere (hypersphere) of radius R_0 and centered at $(a_1, a_2, \ldots, a_n)$

$$s_i = \begin{cases} 0.5 & \textbf{if } \sum_{j=1}^{n} (r_j - a_j)^2 > R_0^2 \\ r_i & \textbf{otherwise} \end{cases}, \; i \in [1, n]$$

Example 6.8: An illustration of colour slicing



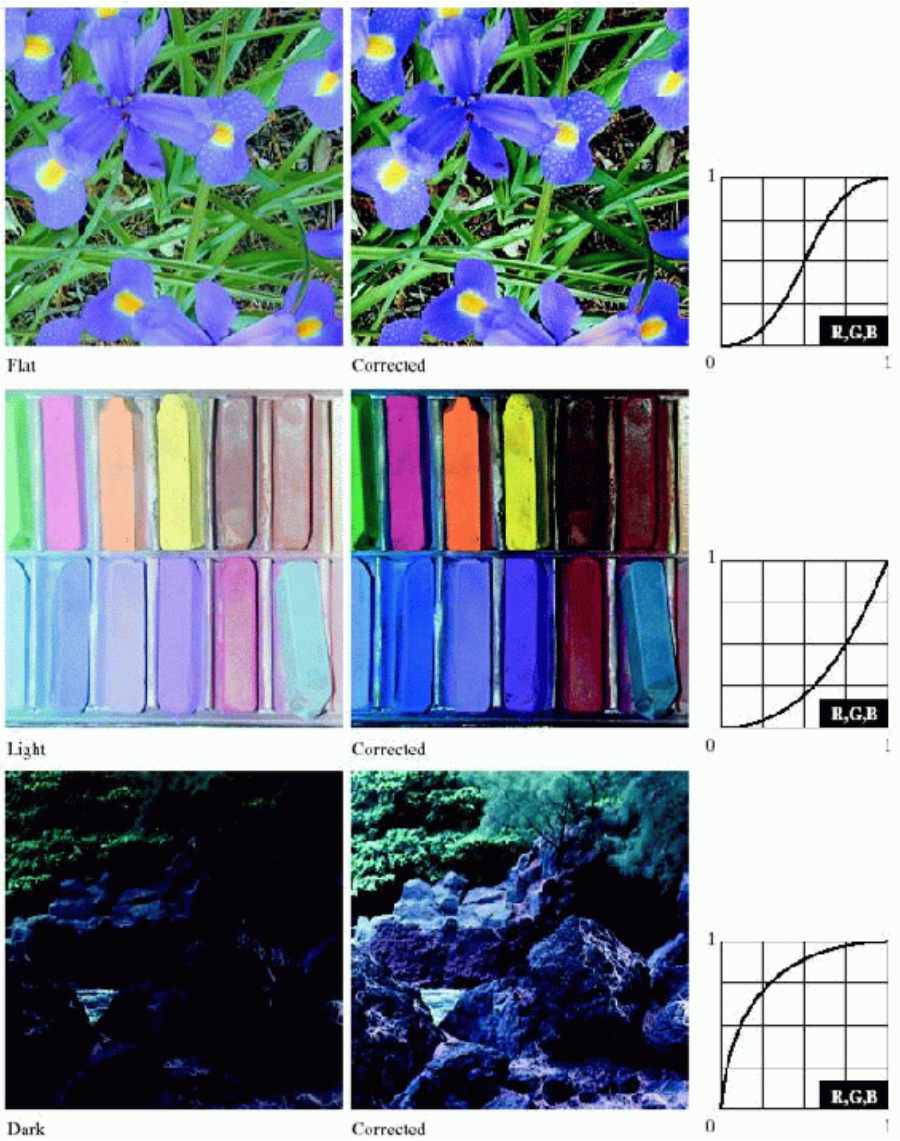
a b

FIGURE 6.34 Color slicing transformations that detect (a) reds within an RGB cube of width $W = 0.2549$ centered at (0.6863, 0.1608, 0.1922), and (b) reds within an RGB sphere of radius 0.1765 centered at the same point. Pixels outside the cube and sphere were replaced by color (0.5, 0.5, 0.5).

6.5.4 Tone and colour corrections

We do not discuss the theoretic aspects on page 455 and immediately proceed to Examples 6.9 (tonal transformations) and 6.10 (colour balancing)...

Example 6.9: Tonal corrections



Example 6.10: Colour balancing (CMYK images)

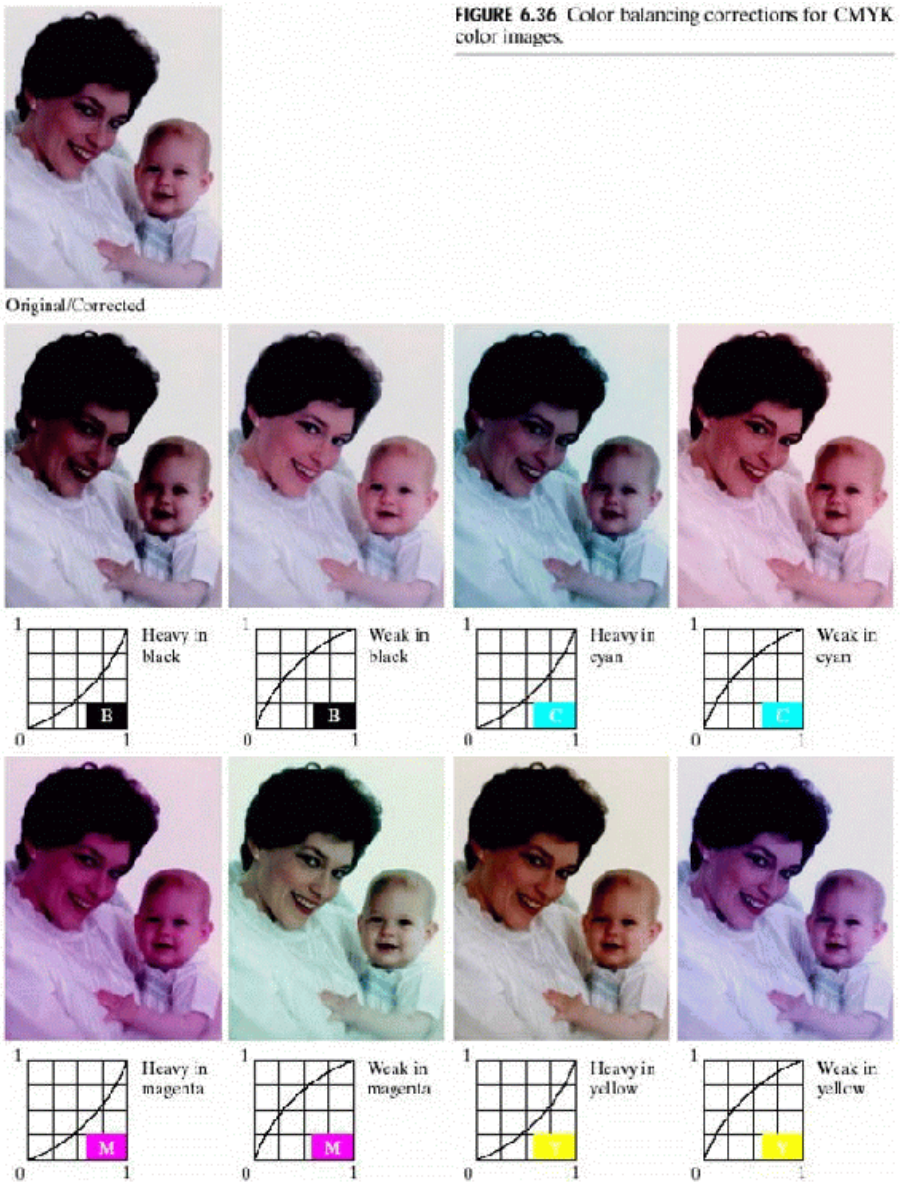
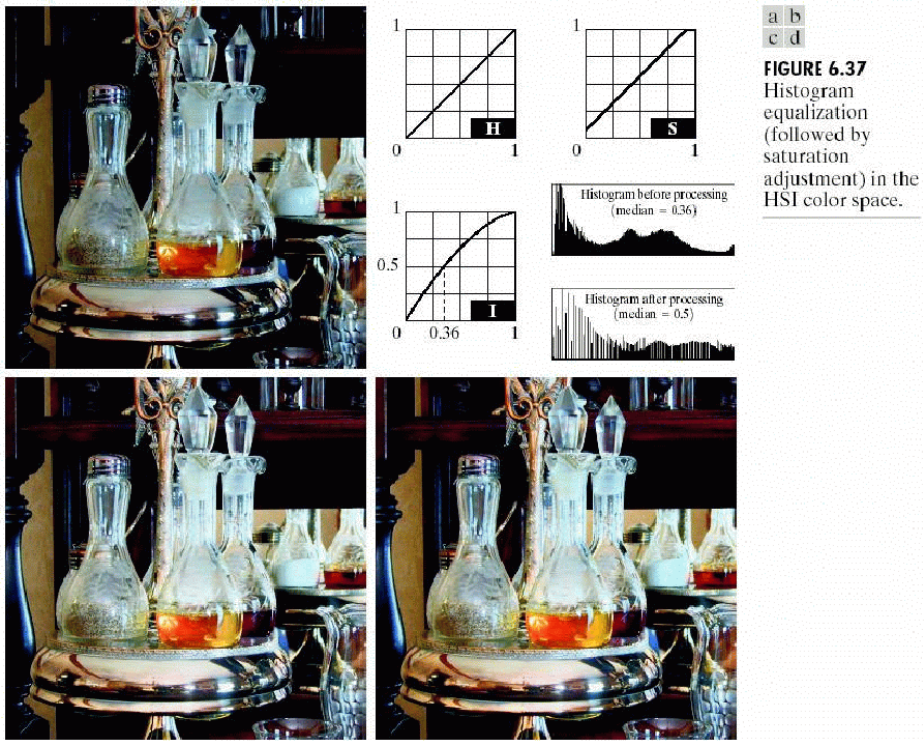


FIGURE 6.36 Color balancing corrections for CMYK color images.

6.5.5 Histogram processing

• Generally unwise to equalize colour components independently: results in erroneous colour • Rather spread colour intensities uniformly and leave the hues unchanged: HSI colour space well-suited for this approach

Example 6.11: Histogram equalization (HSI space)



a b
c d

FIGURE 6.37 Histogram equalization (followed by saturation adjustment) in the HSI color space.

(a) Original image (b)intensity transformation & histograms (c) image after histogram equalization (d) ↑ saturation after histogram equalization