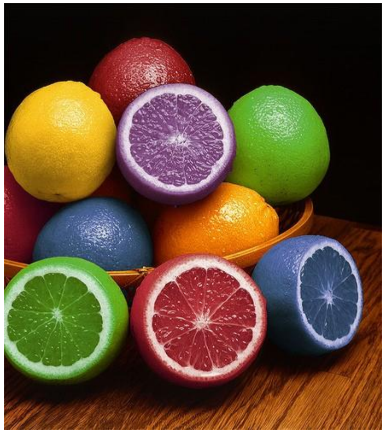
Chapter 6
Color Image Processing

Preview

- Motivation of color image processing
  - Color is a power descriptor that often simplifies object identification and extraction from a scene
  - Human can discern thousands of color shades and intensities, compared to about only two dozen shades of gray



6.1 Color Fundamentals

- Color spectrum

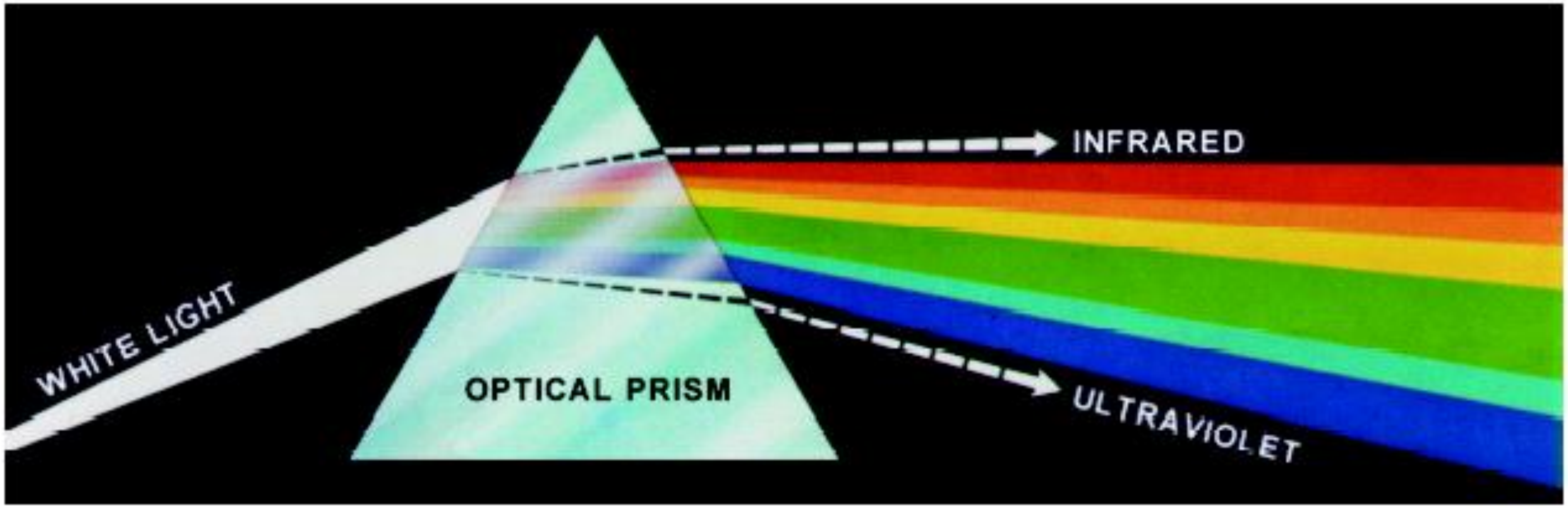


FIGURE 6.1 Color spectrum seen by passing white light through a prism. (Courtesy of the General Electric Co., Lamp Business Division.)

6.1 Color Fundamentals

- Wavelength

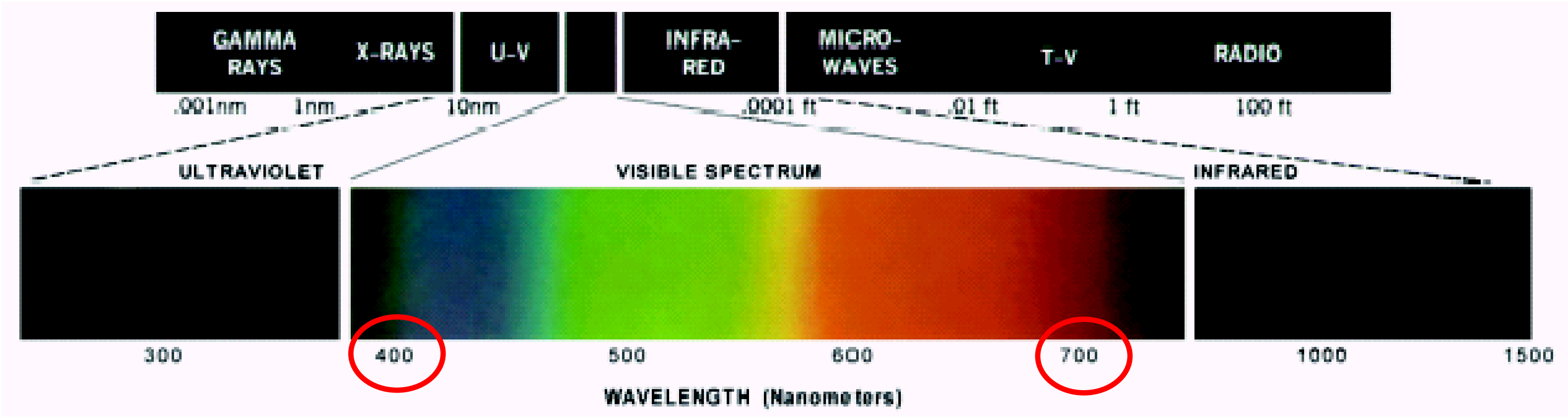


FIGURE 6.2 Wavelengths comprising the visible range of the electromagnetic spectrum. (Courtesy of the General Electric Co., Lamp Business Division.)

6.1 Color Fundamentals

- Quality of a chromatic light source
  1. **Radiance**- the total amount of energy that flows from the light source (watts, W)
  2. **Luminance**- the amount of energy an observer perceives from a light source (lumens, lm)
  3. **Brightness**- a subjective descriptor (achromatic notion of intensity) that is practically impossible to measure

6.1 Color Fundamentals

- **Cones** are the sensors in the eye responsible for color vision
  - 65% of cones are sensitive to red light
  - 33% of cones are sensitive to green light
  - 2% of cones are sensitive to blue light
- Due to the absorption characteristics of human eye, color are seen by as variable combinations of the **primary colors** red (R), green (G), ,and blue (B).

6.1 Color Fundamentals

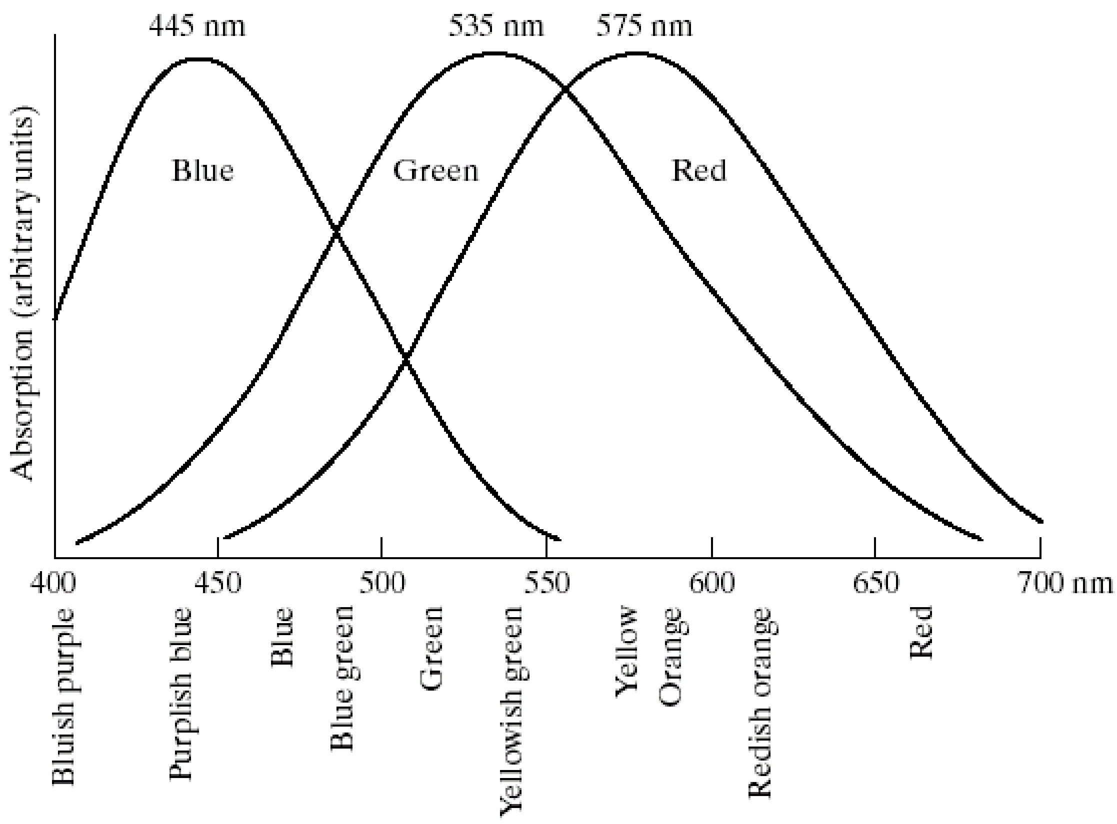
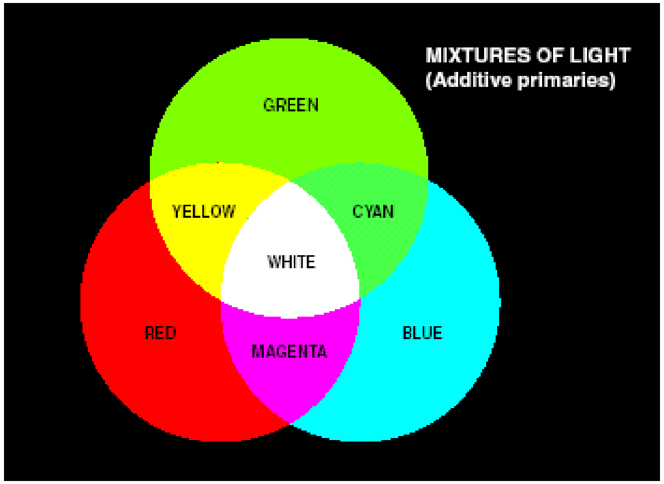


FIGURE 6.3 Absorption of light by the red, green, and blue cones in the human eye as a function of wavelength.

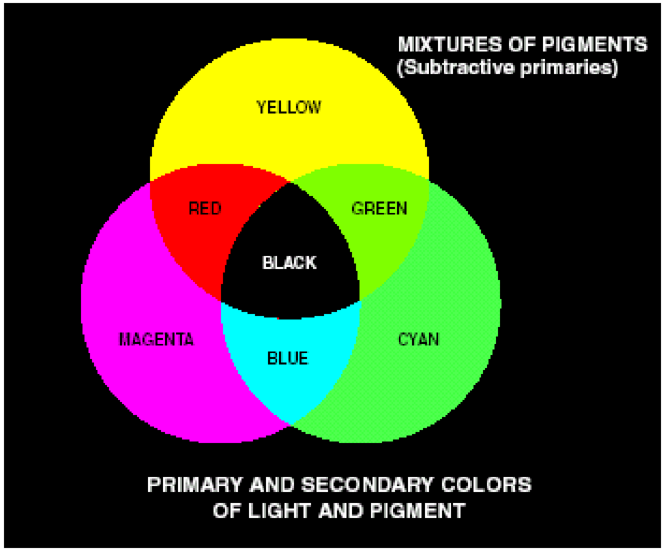
6.1 Color Fundamentals

- CIE : Three primary color:
  - Red: 700 nm
  - Green: 546.1 nm
  - Blue: 435.8 nm
- Additive color system
  - Primary color of light: R, G, B
  - R+G $\Rightarrow$ Y (yellow)
  - R+B $\Rightarrow$ M (magenta)
  - G+B $\Rightarrow$ C (cyan)
  - R+G+B $\Rightarrow$ W (white)



6.1 Color Fundamentals

- Subtractive color system
  - Primary colors of pigments: C, M, Y, K
  - Used for printing
  - C+M $\Rightarrow$ B
  - C+Y $\Rightarrow$ G
  - M+Y $\Rightarrow$ R
  - C+M+Y $\Rightarrow$ B (black)



6.1 Color Fundamentals

- Color discrimination:
  - Brightness: Intensity
  - Hue: dominant wavelength in a mixture of light waves (dominant color as perceived by an observer)
  - Saturation: relative purity of <u>the amount of white light mixed</u> with a hue
    - Pink (red and white)
    - Lavender (violet and white)

6.1 Color Fundamentals

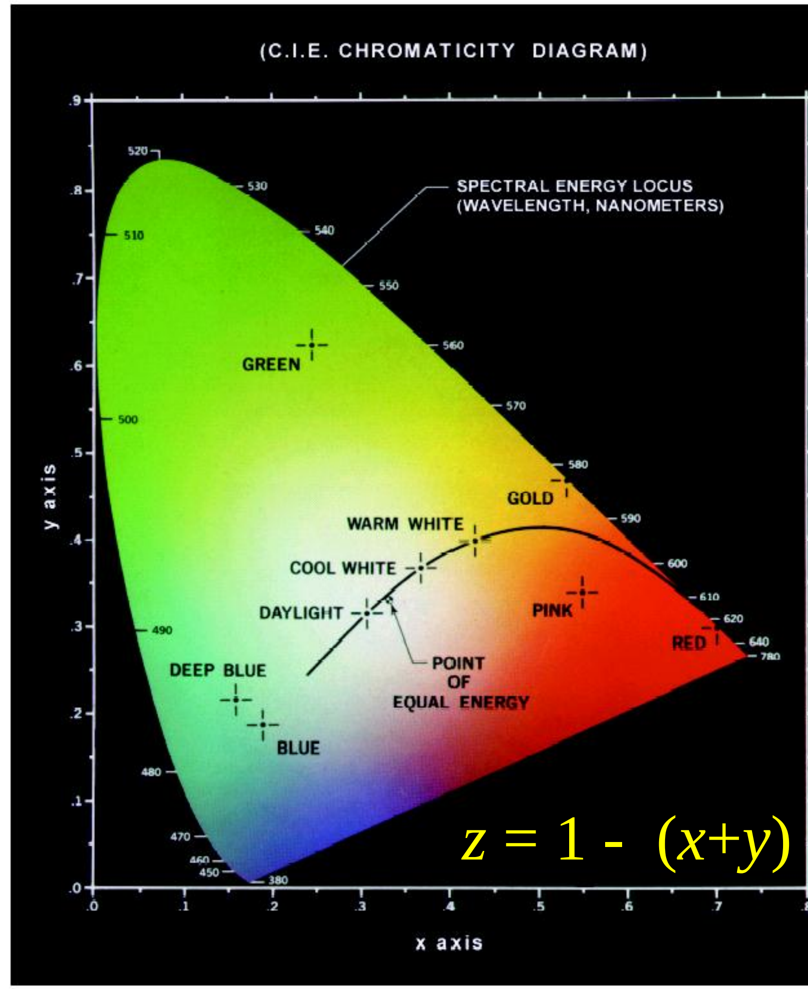
- Color may be characterized with
  - Chromaticity: hue and saturation
  - Brightness
- **Tristimulous values** (X, Y, Z): the amounts of red, green, and blue needed to form any particular color
- **Trichromatic coefficients**:

$$x = \frac{X}{X+Y+Z}, \quad y = \frac{Y}{X+Y+Z}, \quad z = \frac{Z}{X+Y+Z}$$

$$x + y + z = 1$$

6.1 Color Fundamentals

- **CIE chromaticity diagram**
  - Useful for color mixing
  - A straight line segment joining any two points in the diagram defines all the different color variations that can be obtained by combining these two colors additively



6.1 Color Fundamentals

- Any color inside the triangle constructed by three color points can be produced by various combinations of the three initial colors
- **Color gamut** for RGB monitor
- **Color gamut** for color printing devices

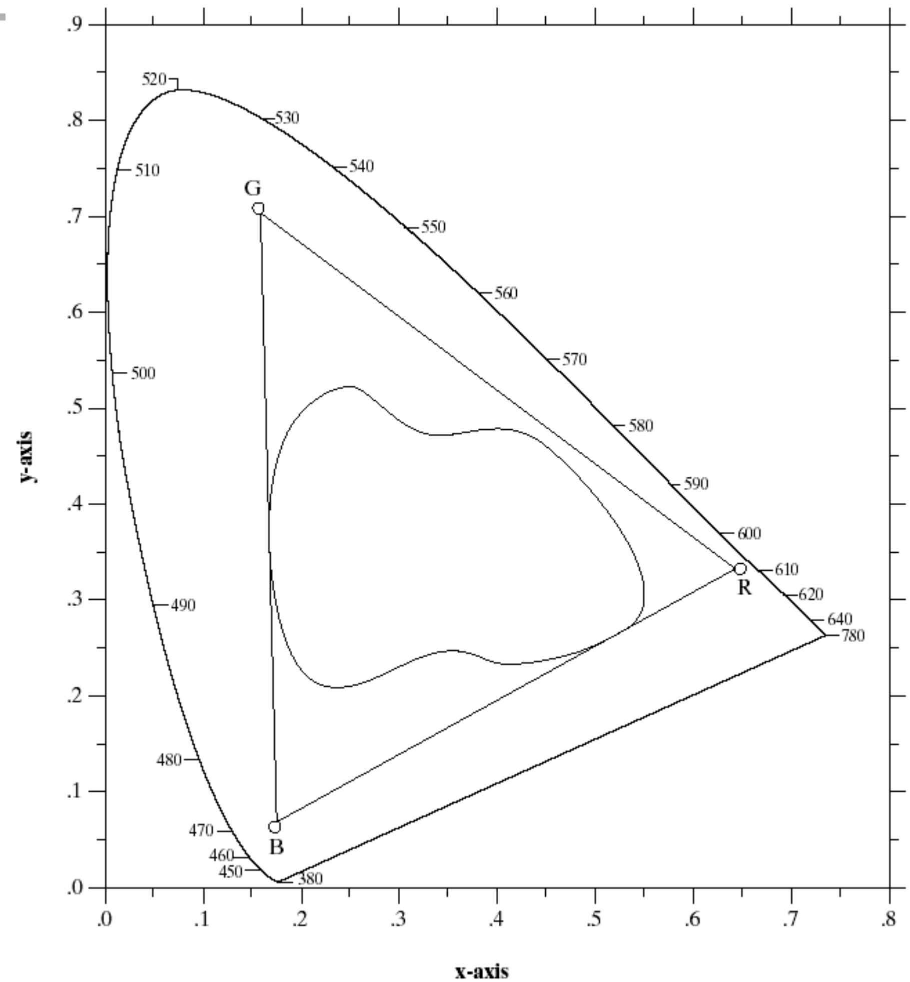


FIGURE 6.6 Typical color gamut of color monitors (triangle) and color printing devices (irregular region).

6.2 Color Model

- **Color model (color space, color system)** – a specification of a coordinate system and a subspace within that system where each color is represented by a single point
  - RGB (red, green, blue) – color monitors, color video cameras
  - CMY (cyan, magenta, yellow), CMYK (cyan, magenta, yellow, black) – color printing
  - HSI (hue, saturation, intensity) – corresponds with humans describe and interpret color

6.2.1 The RGB color model

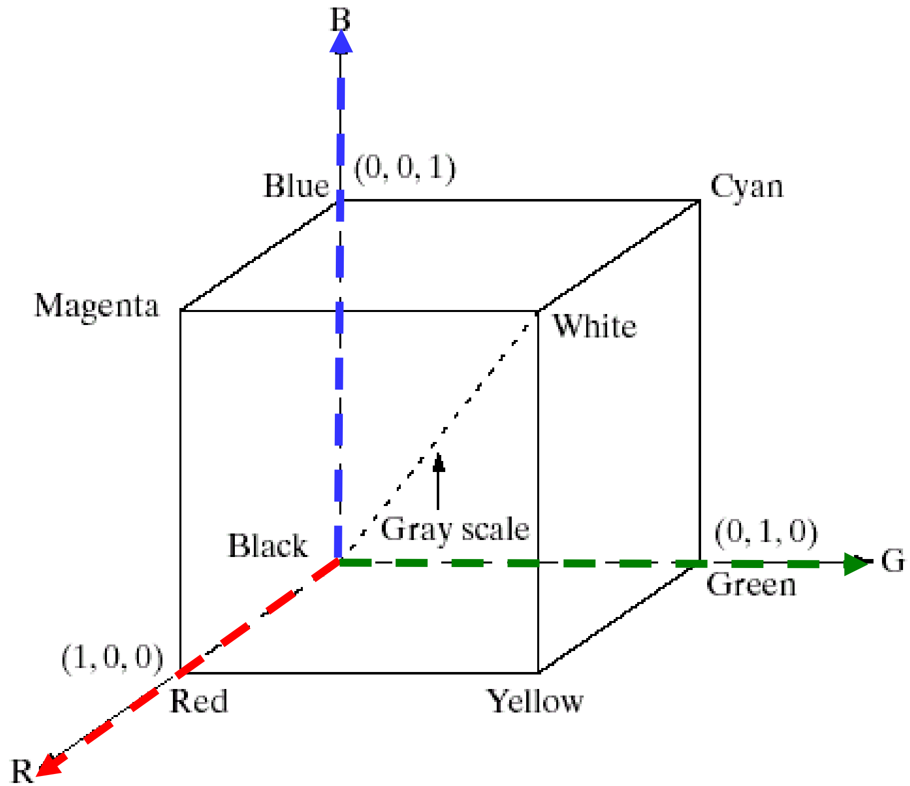


FIGURE 6.7 Schematic of the RGB color cube. Points along the main diagonal have gray values, from black at the origin to white at point (1, 1, 1).

6.2.1 The RGB color model

- Full color: 24 bits

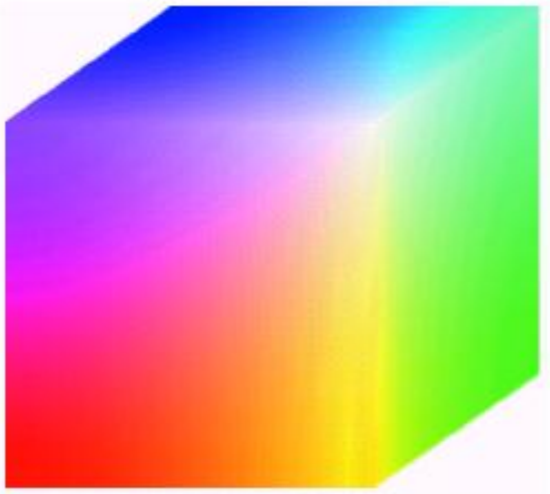


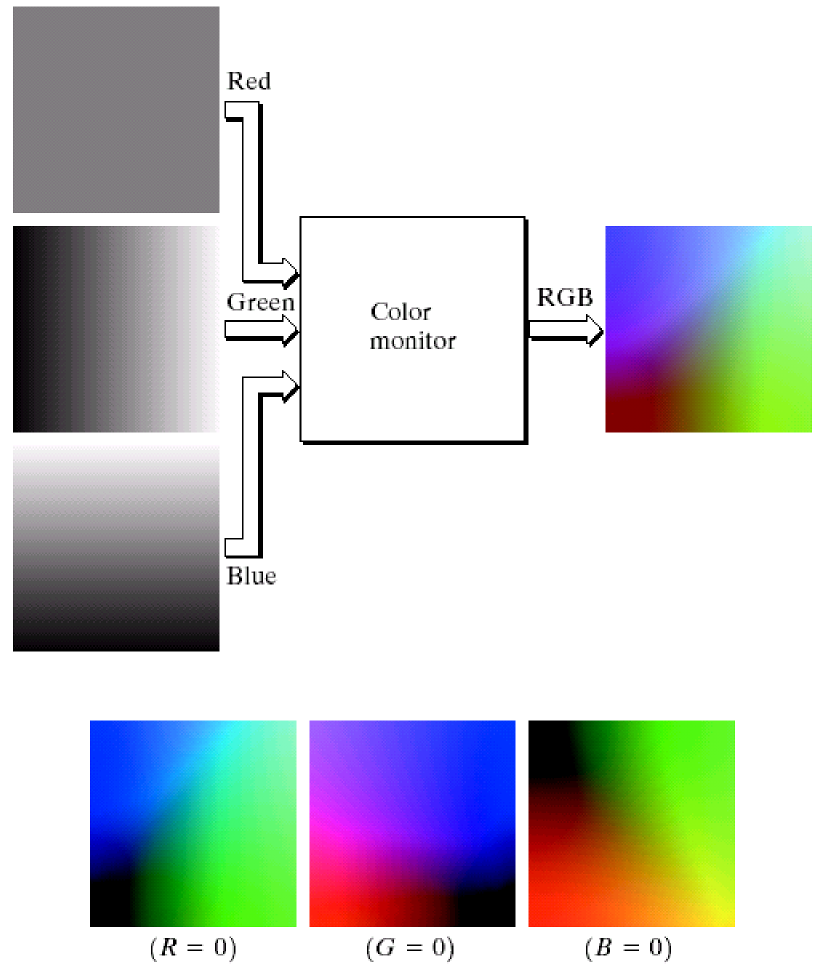
FIGURE 6.8 RGB 24-bit color cube.

6.2.1 The RGB color model

- Acquiring a color image

a
b

FIGURE 6.9
(a) Generating the RGB image of the cross-sectional color plane (127, *G*, *B*). (b) The three hidden surface planes in the color cube of Fig. 6.8.



6.2.1 The RGB color model

- Safe RGB colors (all-system-safe colors) – a subset of colors that are likely to be reproduced faithfully, reasonably independently of viewer hardware capabilities
- In Internet applications, called safe Web colors or safe browser colors
- 216 safe RGB colors

Number System	Color Equivalents					
Hex	00	33	66	99	CC	FF
Decimal	0	51	102	153	204	255

TABLE 6.1 Valid values of each RGB component in a safe color.

6.2.1 The RGB color model

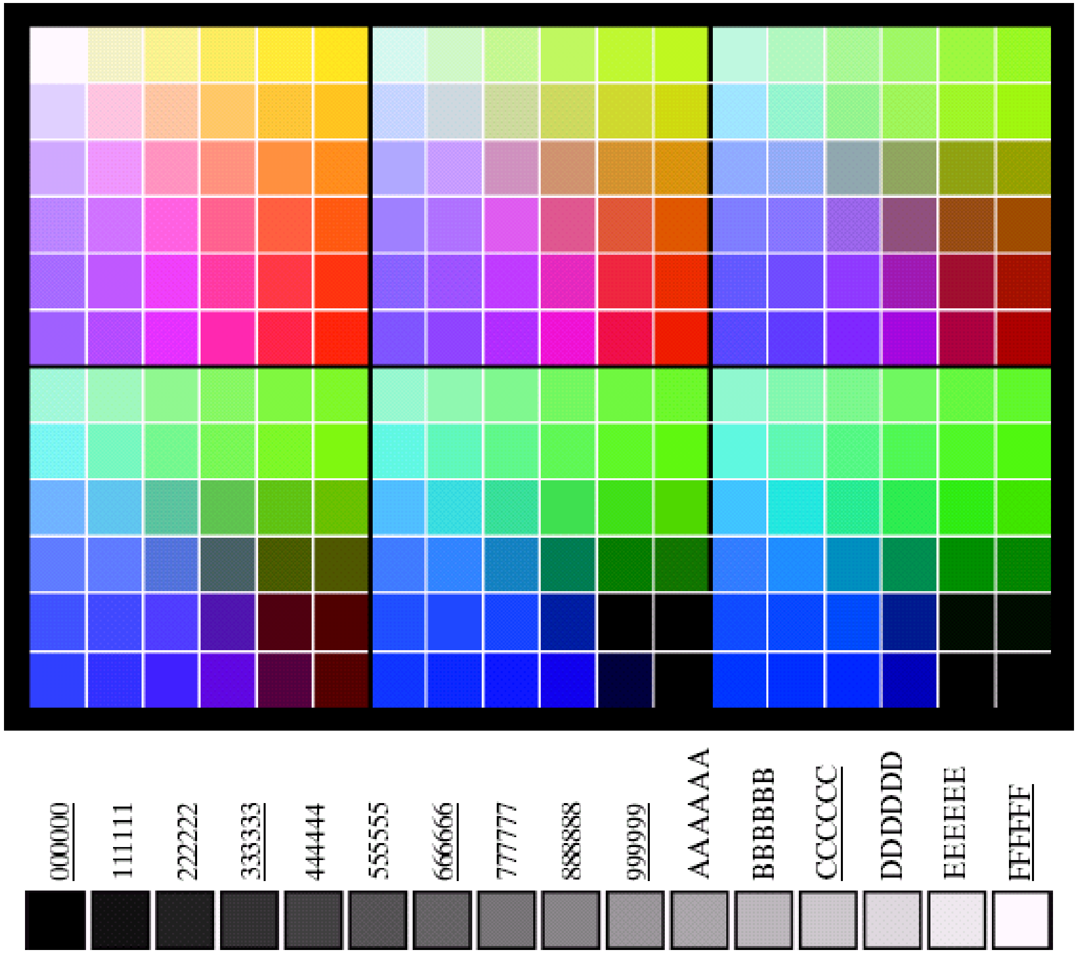


FIGURE 6.10
(a) The 216 safe RGB colors.
(b) All the grays in the 256-color RGB system (grays that are part of the safe color group are shown underlined).

6.2.1 The RGB color model

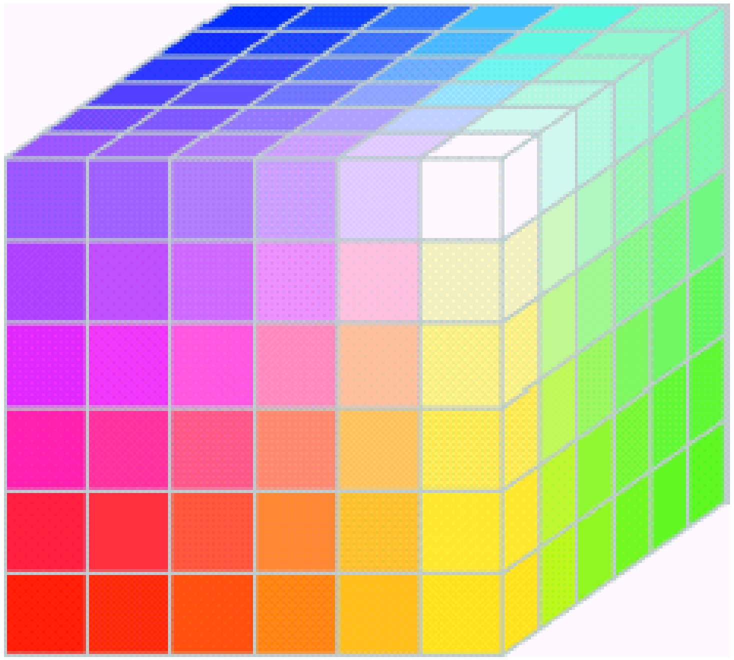


FIGURE 6.11 The RGB safe-color cube.

6.2.2 The CMY and CMYK Color Models

- **CMY** – secondary colors of light or primary colors of pigments

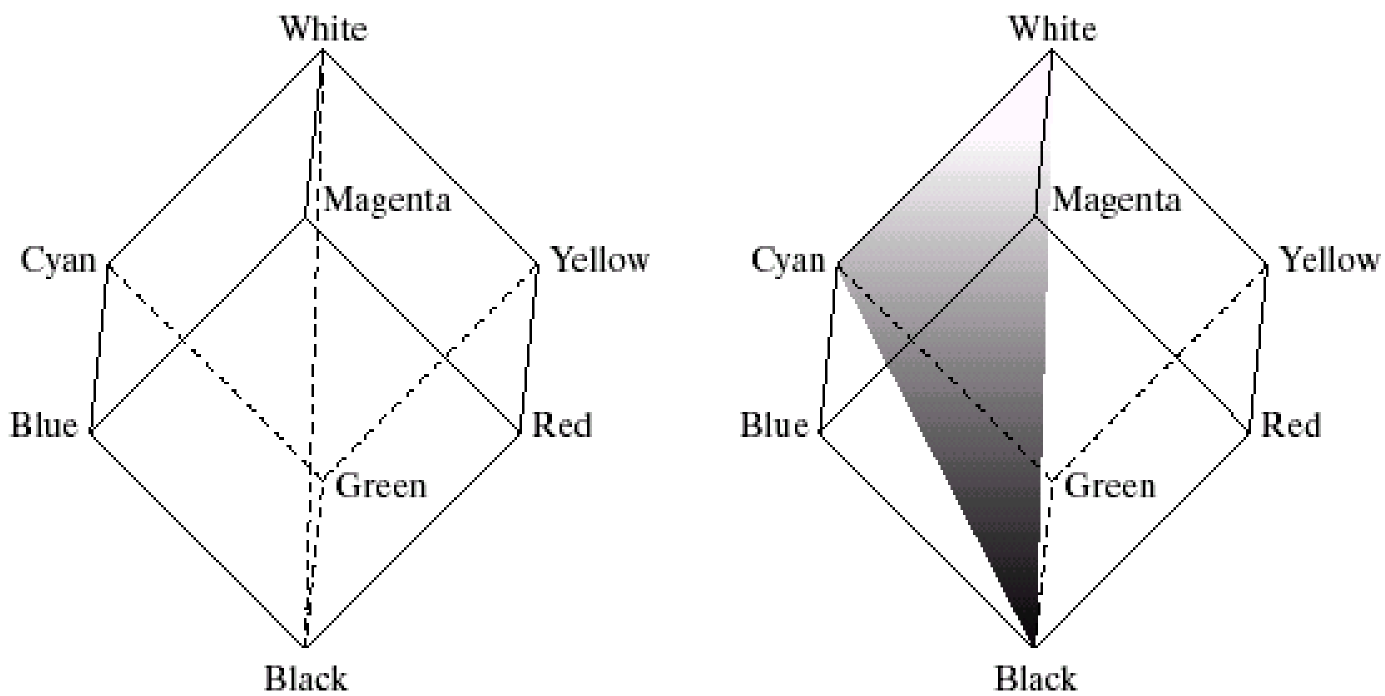
$$\begin{bmatrix} C \\ M \\ Y \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} - \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

- **CMYK** – CMY + black

6.2.3 HSI Color Model

- **Intensity axis**: the line of joining the black and white vertices
- **Intensity** for a color *p*: Constructing a plane containing the point *p* and perpendicular to the intensity axis. The position of the intersection point will determine the intensity.
- **Saturation** for a color *p*: distance from the intensity axis
- **Hue** for a color *p*: The same hue value on the plane shown in Fig. 6.12(b)

6.2.3 HSI Color Model



a b

FIGURE 6.12 Conceptual relationships between the RGB and HSI color models.

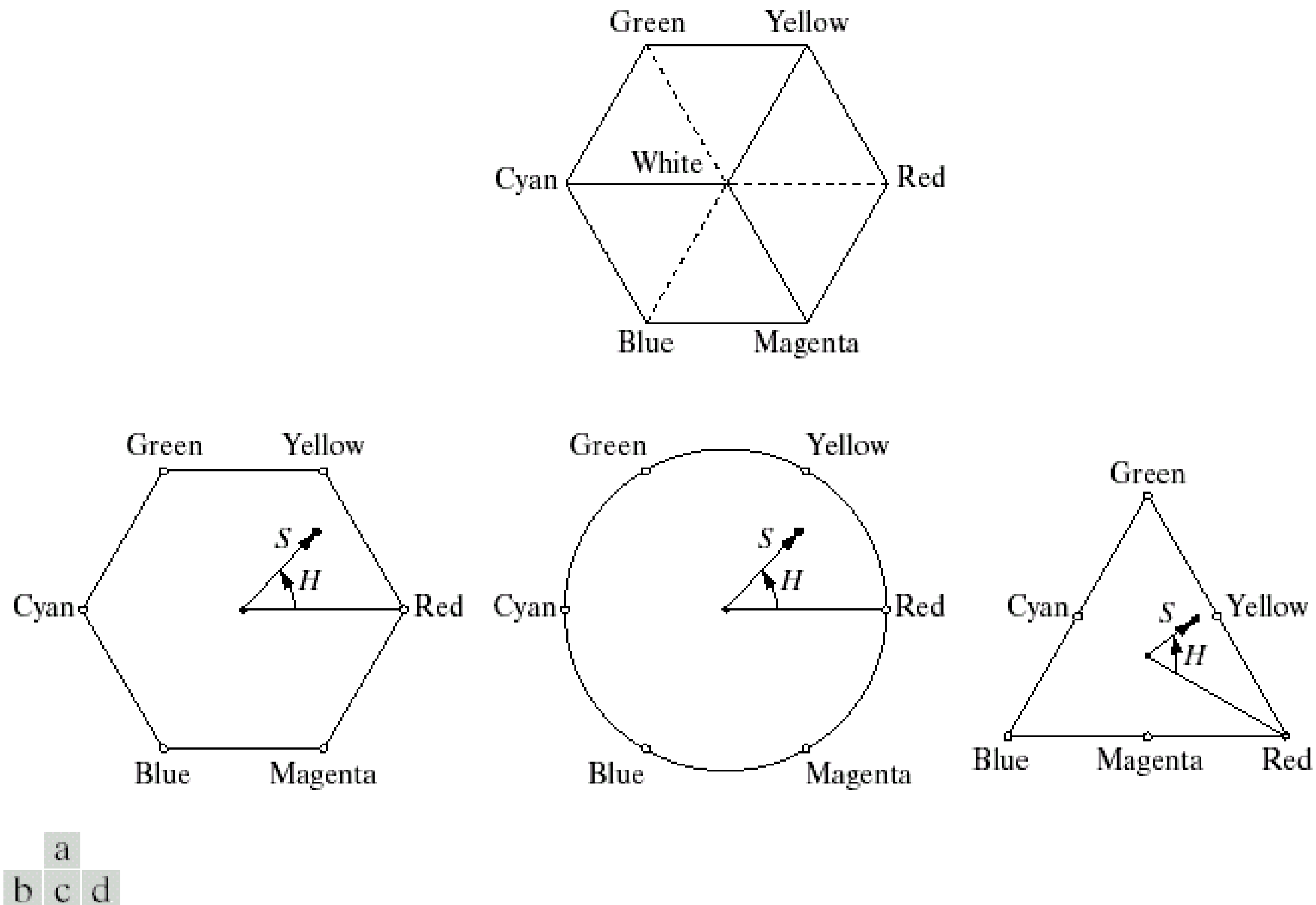
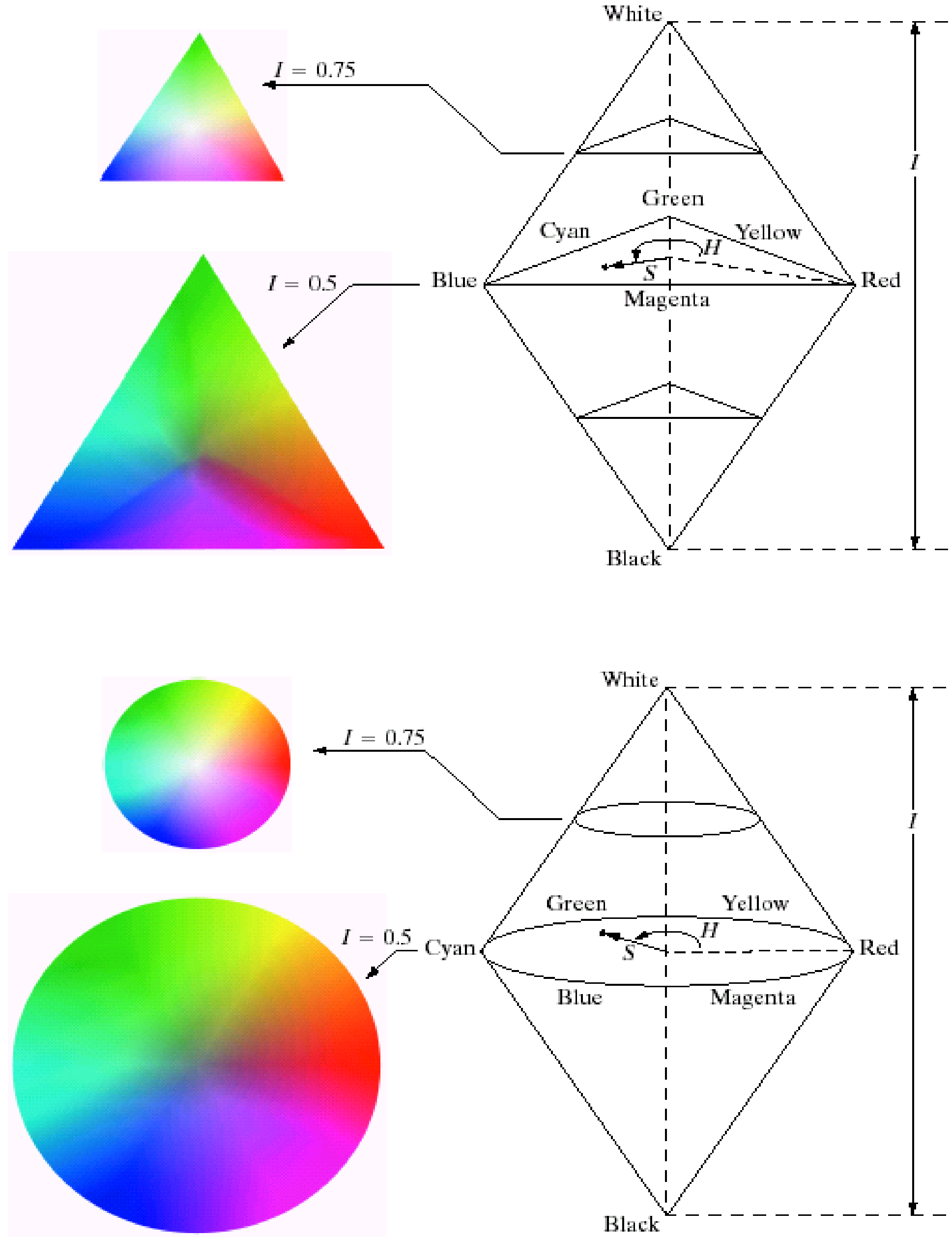


FIGURE 6.13 Hue and saturation in the HSI color model. The dot is an arbitrary color point. The angle from the red axis gives the hue, and the length of the vector is the saturation. The intensity of all colors in any of these planes is given by the position of the plane on the vertical intensity axis.



a
b

FIGURE 6.14 The HSI color model based on (a) triangular and (b) circular color planes. The triangles and circles are perpendicular to the vertical intensity axis.

6.2.3 HSI Color Model

- Converting colors from RGB to HSI

$$H = \begin{cases} \theta & \text{if } B \le G \\ 360 - \theta & \text{if } B > G \end{cases}$$

$$\theta = \cos^{-1}\left\{ \frac{\frac{1}{2}[(R-G)+(R-B)]}{[(R-G)^2+(R-B)(R-G)]^{\frac{1}{2}}} \right\}$$

$$S = 1 - \frac{3}{(R+G+B)}[\min(R, G, B)]$$

$$I = \frac{1}{3}(R+G+B)$$

6.2.3 HSI Color Model

- Converting colors from HSI to RGB

1. RB sector ($0^o \le H < 120^o$):

$$B = I(1 - S)$$

$$R = I[1 + \frac{S \cos H}{\cos(60^o - H)}]$$

$$G = 1 - (R + B)$$

2. GB sector ($120^o \le H < 240^o$):

$$H = H - 120°$$

$$R = I(1 - S)$$

$$G = I[1 + \frac{S \cos H}{\cos(60^o - H)}]$$

$$B = 1 - (R + G)$$

3. BR sector ($240^o \le H \le 360^o$):

$$H = H - 240°$$

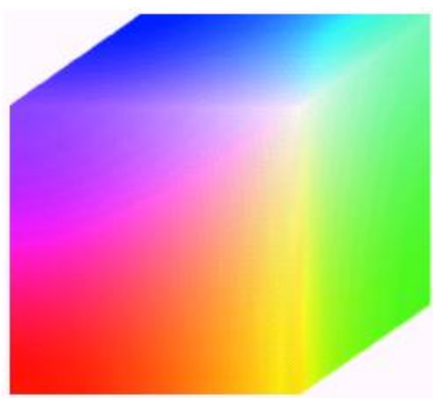
$$G = I(1 - S)$$

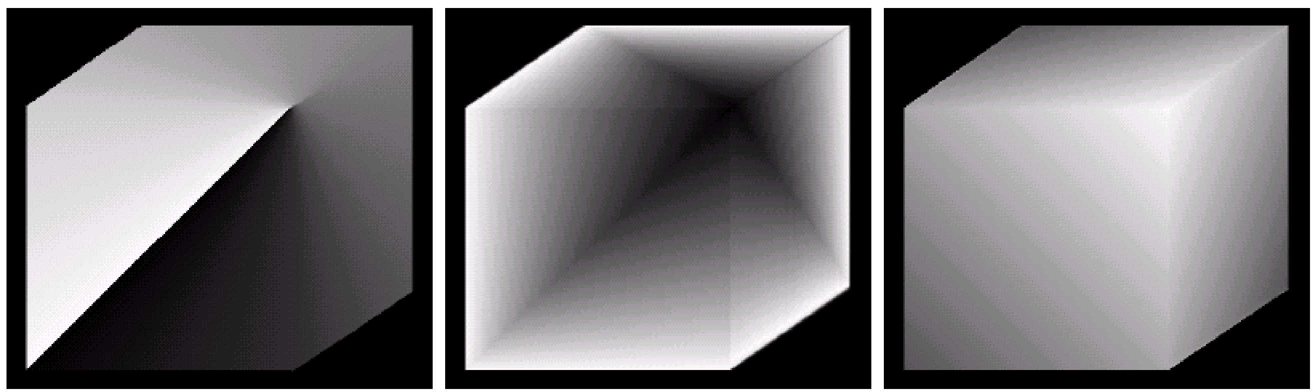
$$B = I[1 + \frac{S \cos H}{\cos(60^o - H)}]$$

$$R = 1 - (G + B)$$

6.2.3 HSI Color Model

- An example



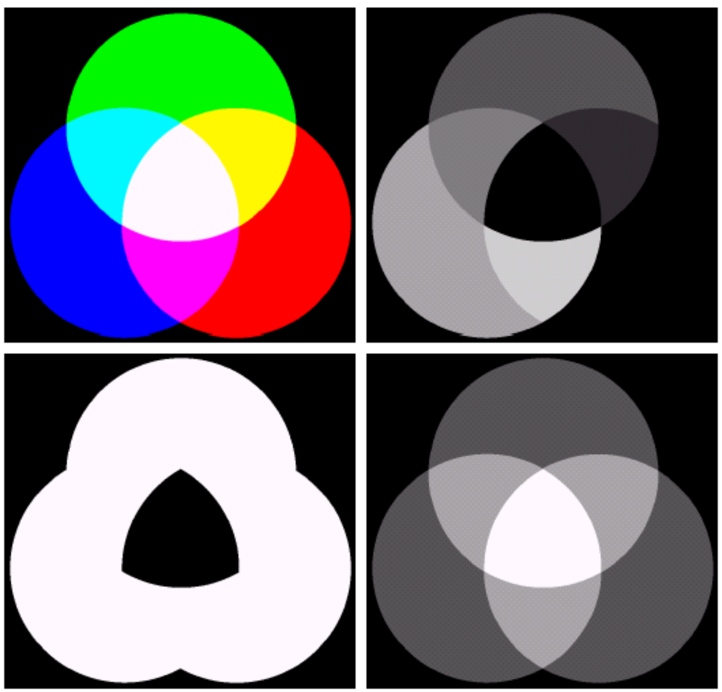


a b c

FIGURE 6.15 HSI components of the image in Fig. 6.8. (a) Hue, (b) saturation, and (c) intensity images.

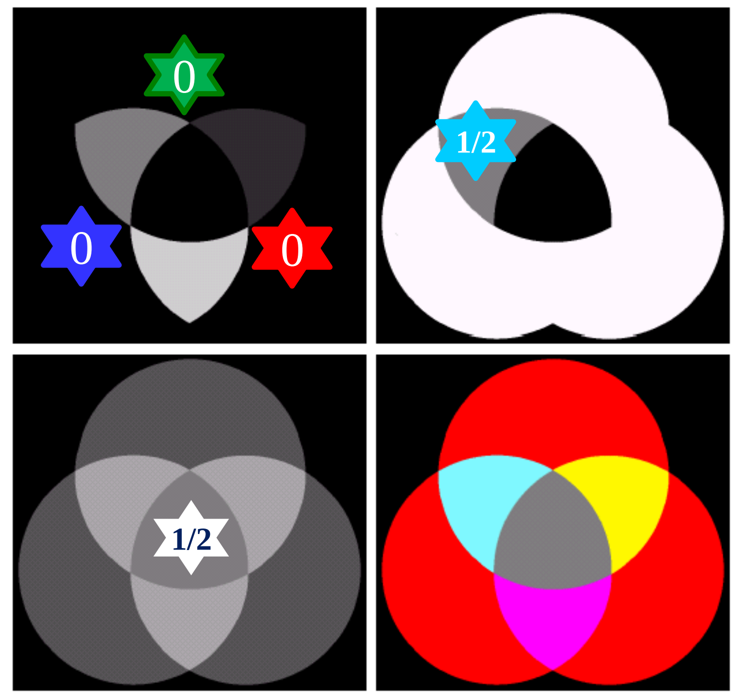
6.2.3 HSI Color Model

- Manipulating HSI component images



a b
c d

FIGURE 6.16 (a) RGB image and the components of its corresponding HSI image: (b) hue, (c) saturation, and (d) intensity.



a b
c d

FIGURE 6.17 (a)–(c) Modified HSI component images. (d) Resulting RGB image. (See Fig. 6.16 for the original HSI images.)

6.3 Pseudocolor Image Processing

- The mapping process of intensity to color
  - Intensity slicing
  - Gray level to color transformations

6.3.1 Intensity Slicing

- Intensity Slicing

$$f(x,y)=c_k,\ \ if\ \ f(x,y)\in V_k=\{l\,|\,k_1\le l\le k_2\}$$

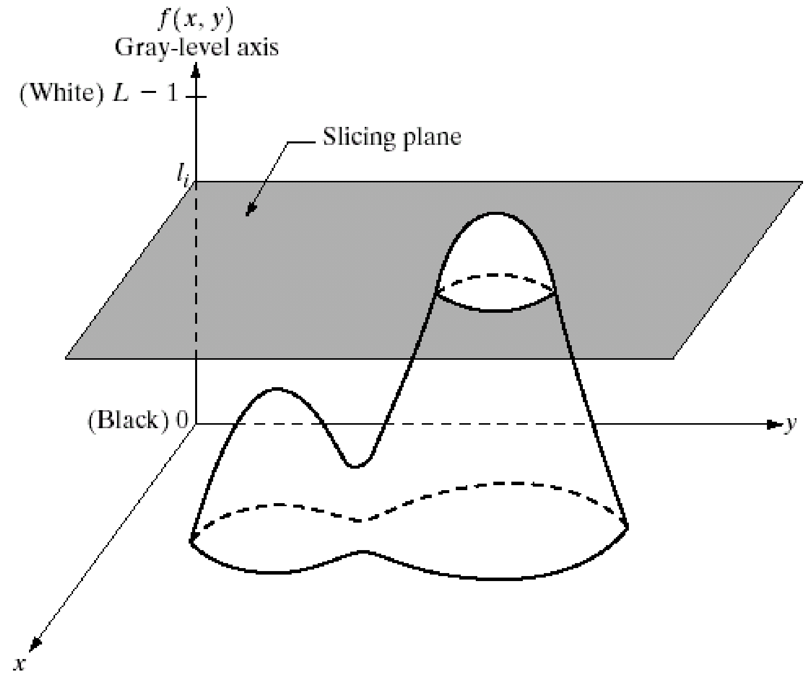


FIGURE 6.18 Geometric interpretation of the intensity-slicing technique.

6.3.1 Intensity Slicing

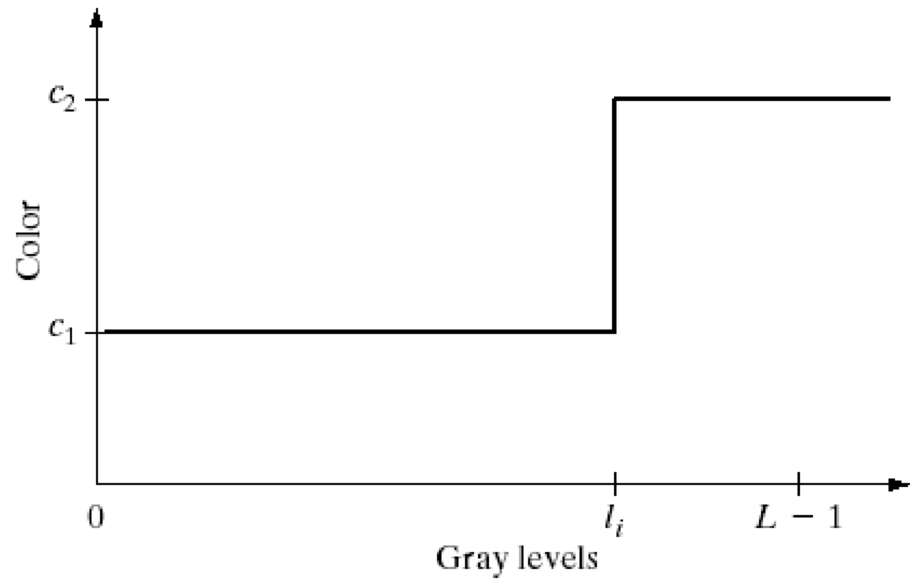
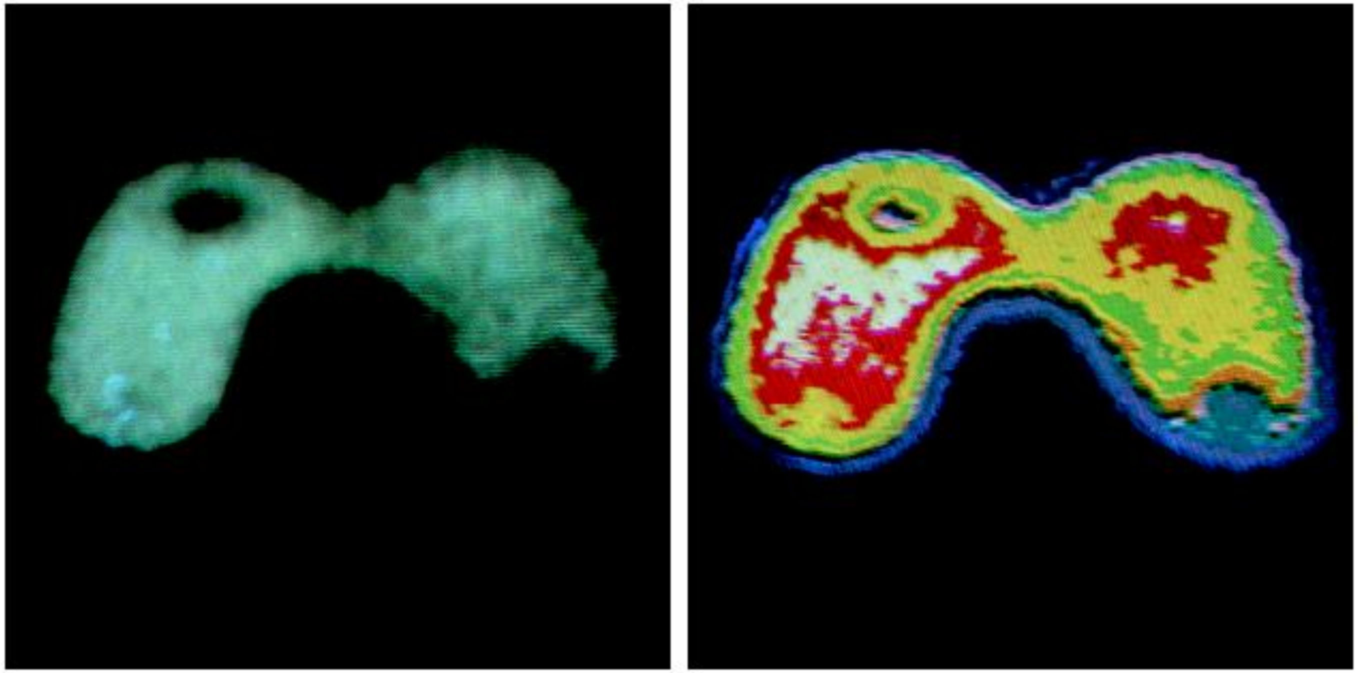


FIGURE 6.19 An alternative representation of the intensity-slicing technique.

Ex. 6.3

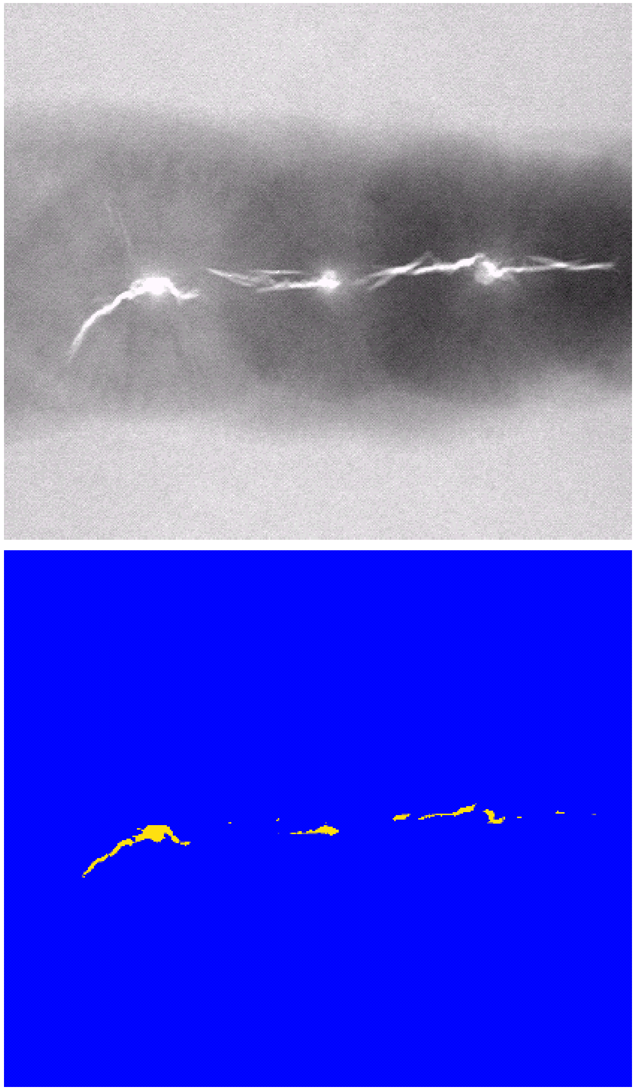


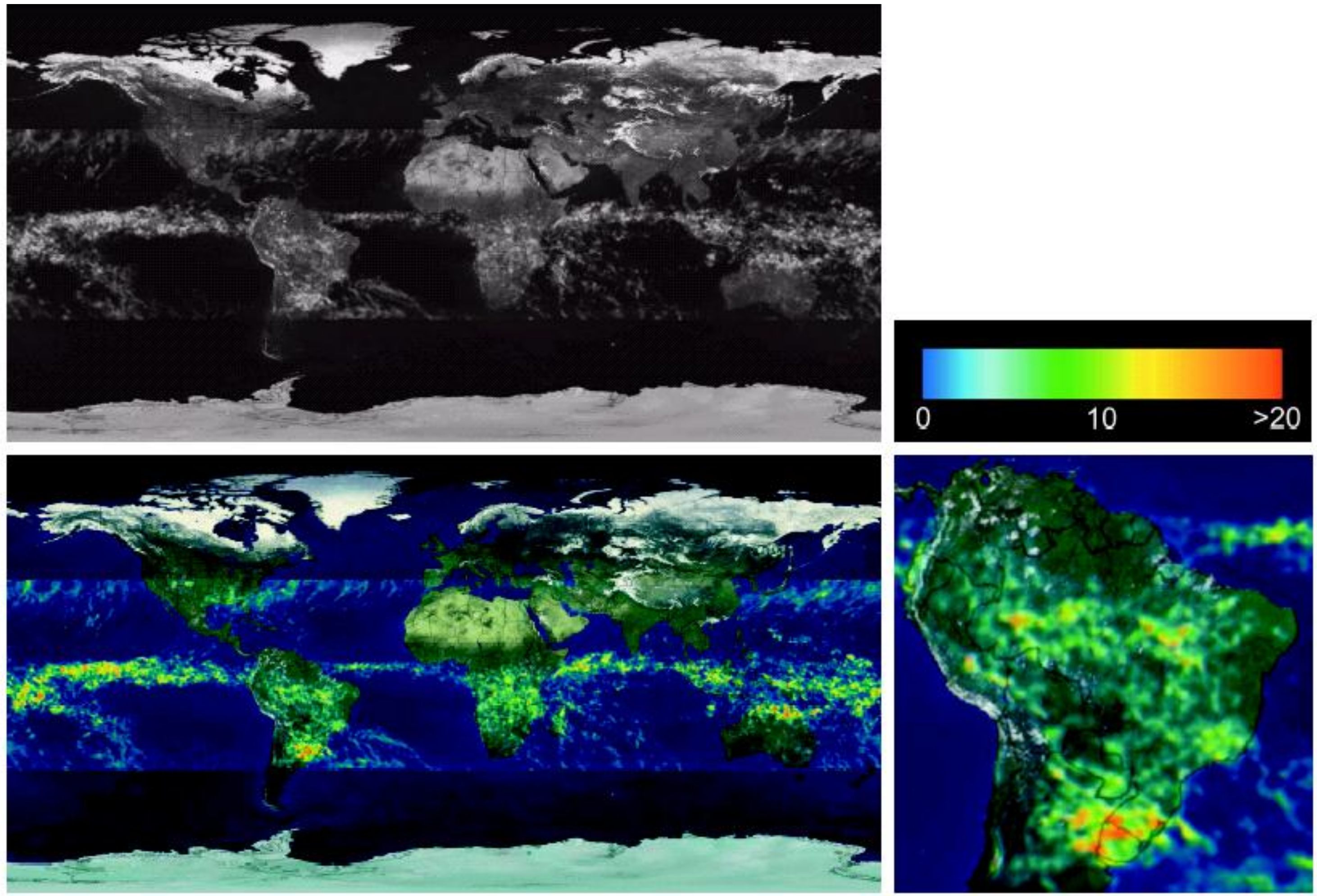
a b

FIGURE 6.20 (a) Monochrome image of the Picker Thyroid Phantom. (b) Result of density slicing into eight colors. (Courtesy of Dr. J. L. Blankenship, Instrumentation and Controls Division, Oak Ridge National Laboratory.)

a
b

FIGURE 6.21 (a) Monochrome X-ray image of a weld. (b) Result of color coding. (Original image courtesy of X-TEK Systems, Ltd.)





a b
c d

FIGURE 6.22 (a) Gray-scale image in which intensity (in the lighter horizontal band shown) corresponds to average monthly rainfall. (b) Colors assigned to intensity values. (c) Color-coded image. (d) Zoom of the South America region. (Courtesy of NASA.)

6.3.2 Gray level to color transformation

- Ex. Fig. 6.25
  - Color transformation
    - Phase
    - Freq.

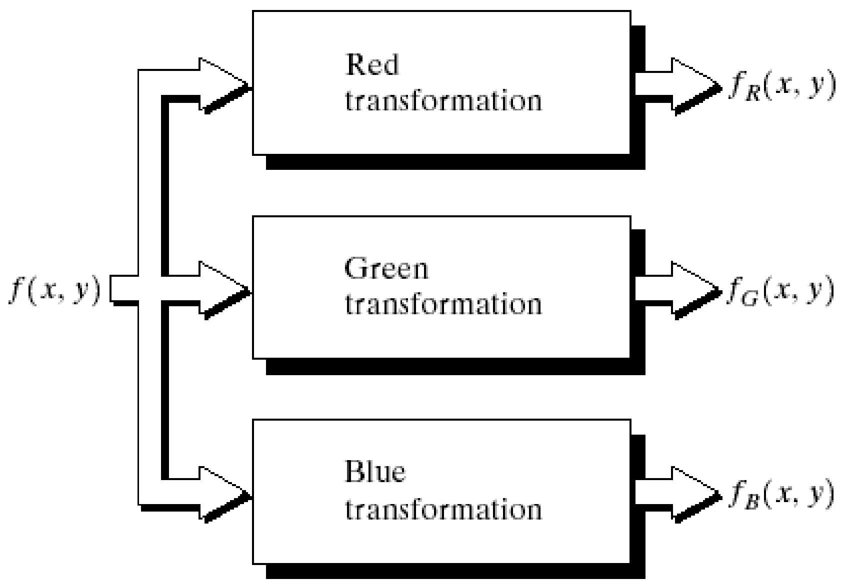
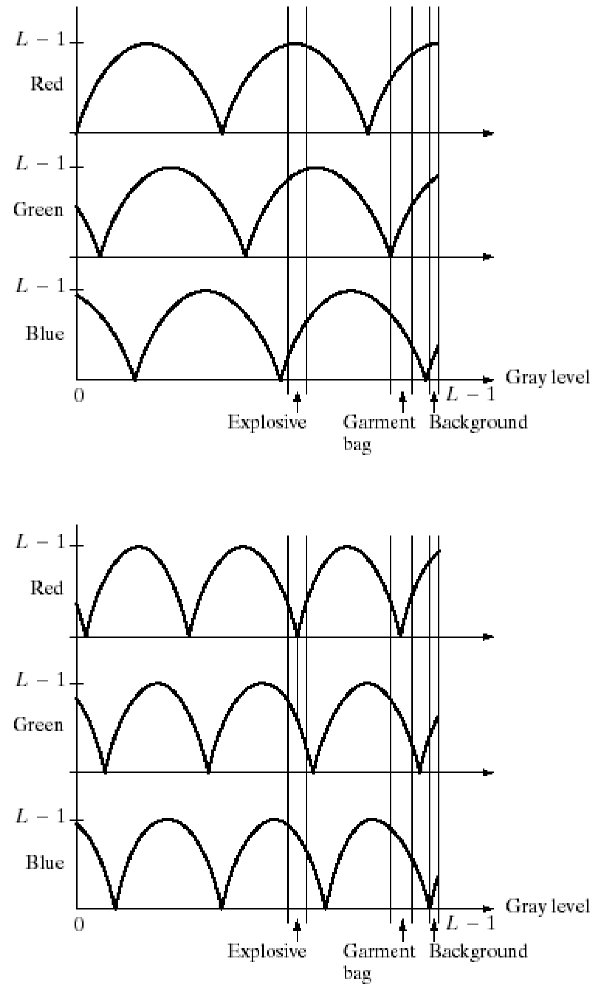
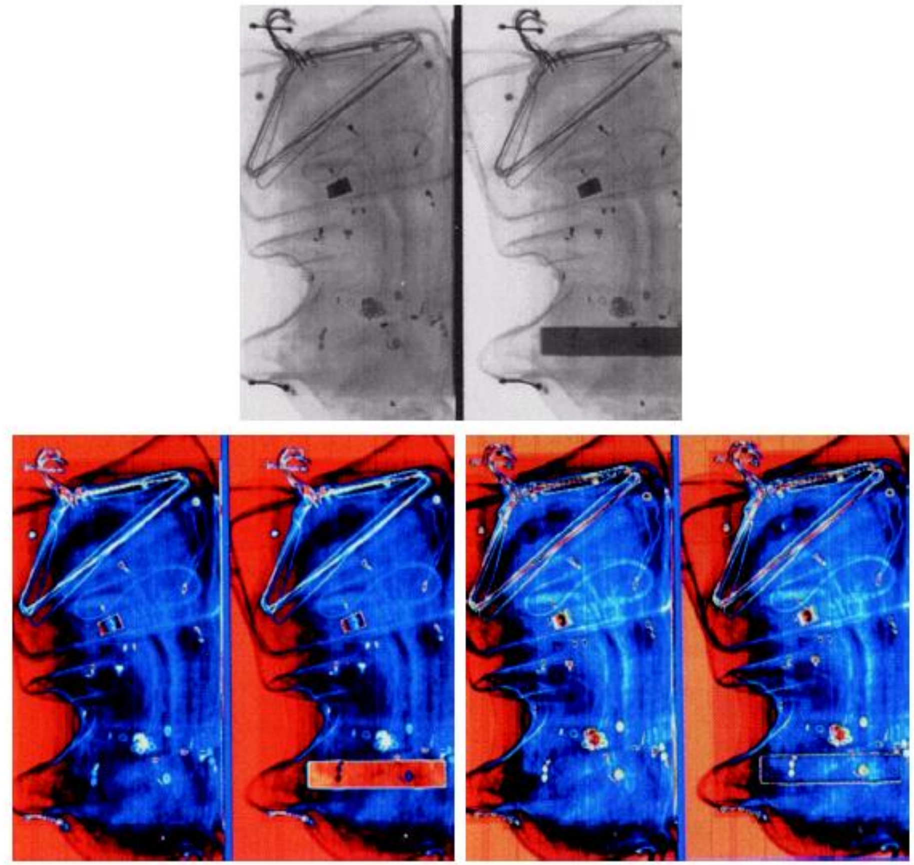


FIGURE 6.23 Functional block diagram for pseudocolor image processing. f_R, f_G, and f_B are fed into the corresponding red, green, and blue inputs of an RGB color monitor.



a
b

FIGURE 6.25 Transformation functions used to obtain the images in Fig. 6.24.



ı
c

URE 6.24 Pseudocolor enhancement by using the gray-level to color transformations Fig. 6.25. (Original image courtesy of Dr. Mike Hurwitz, Westinghouse.)

- Multiple-Monochrome Image-based Pseudocolor transformation: The images acquired by various kinds of spectral bands.

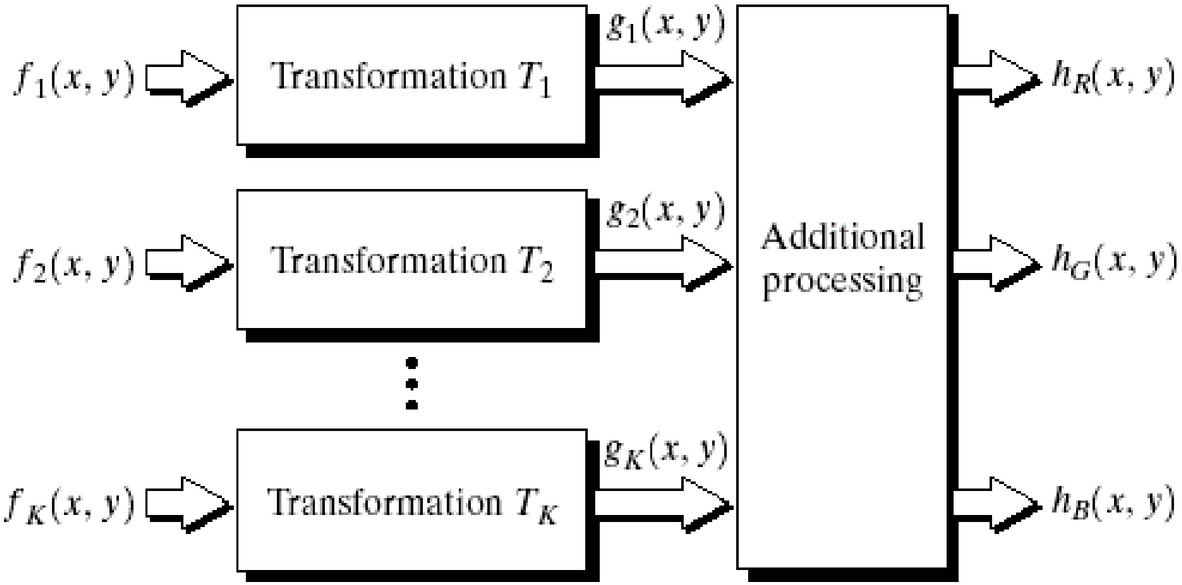
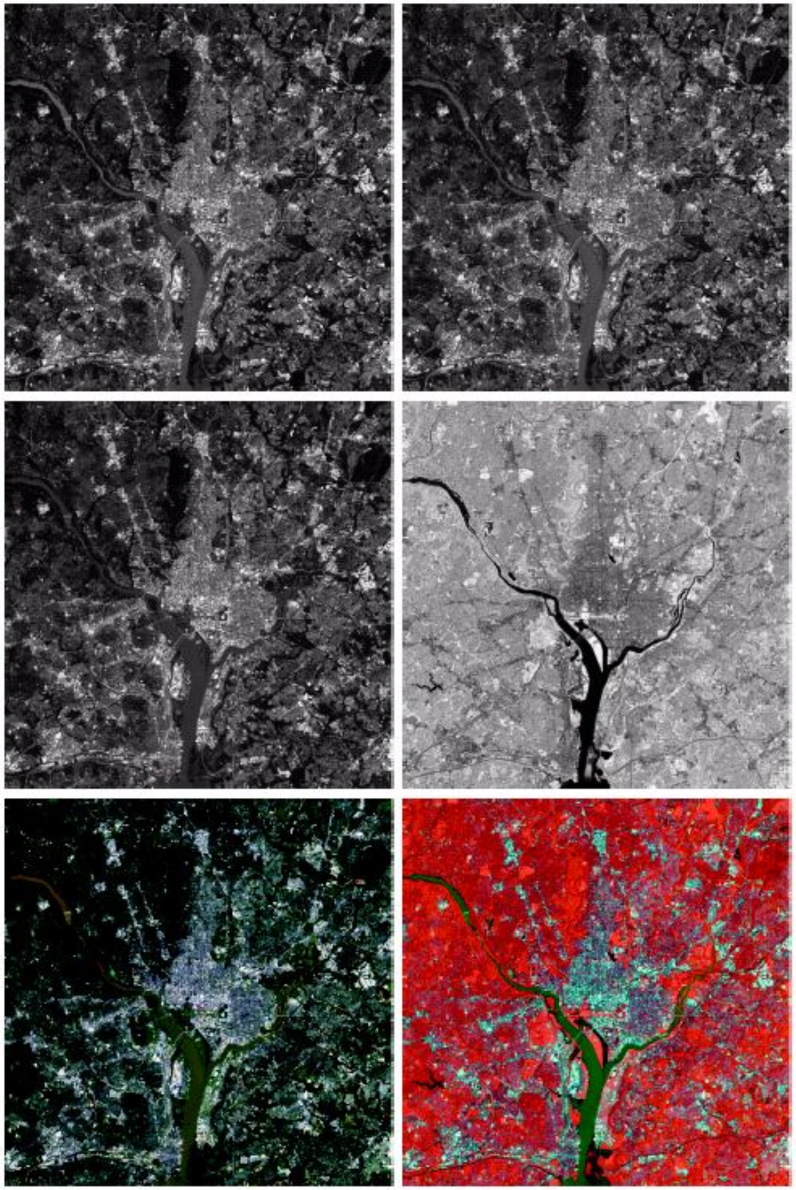


FIGURE 6.26 A pseudocolor coding approach used when several monochrome images are available.

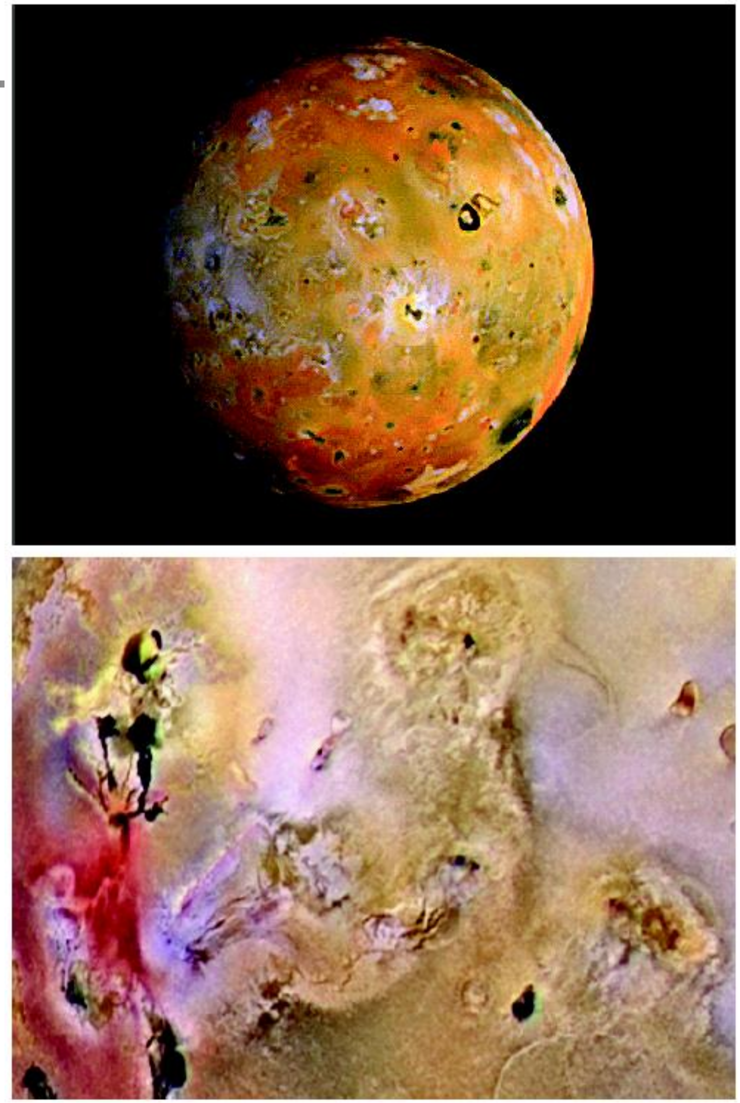
- Ex. Images of Washington



a b
c d
e f

FIGURE 6.27 (a)–(d) Images in bands 1–4 in Fig. 1.10 (see Table 1.1). (e) Color composite image obtained by treating (a), (b), and (c) as the red, green, blue components of an RGB image. (f) Image obtained in the same manner, but using in the red channel the near-infrared image in (d). (Original multispectral images courtesy of NASA.)

- Ex. Jupiter moon



a
b

FIGURE 6.28 (a) Pseudocolor rendition of Jupiter Moon Io. (b) A close-up. (Courtesy of NASA.)

6.4 Basics of Full-Color Image Processing

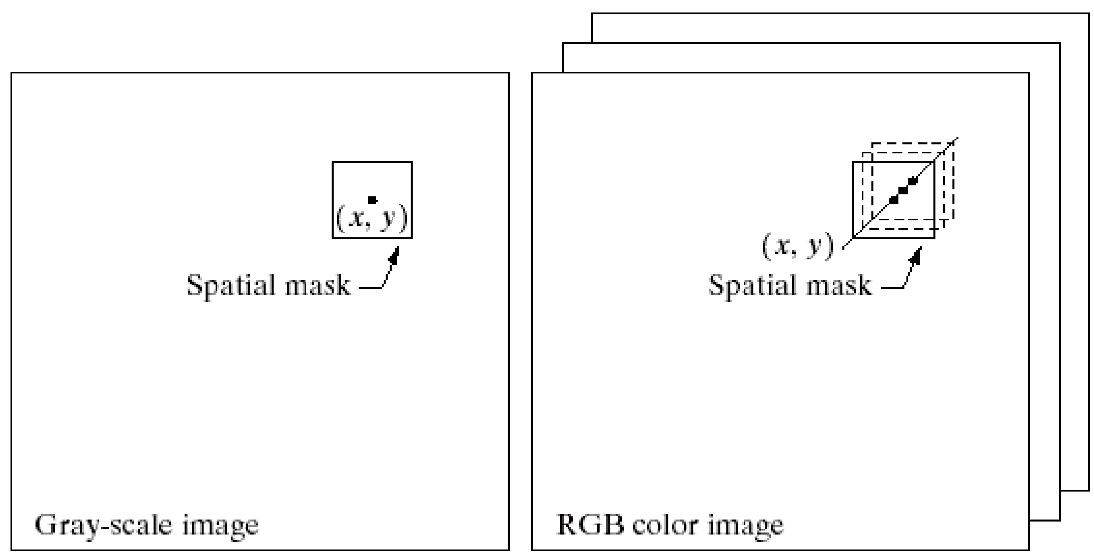
- Full-color image processing approaches fall into two major categories
  1. Per-color-component processing – process each component image individually and then form a composite processed color image from the individually processed components
  2. Vector-based processing – work with color pixels (represented by a vector in the RGB system) directly

6.4 Basics of Full-Color Image Processing

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

a b

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



6.5 Color Transformation

- Color transformations can be modeled using the expression:

  $$g(x,y) = T[f(x,y)]$$

- Color transformation:

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

  - s_i: color component of g(x,y)
  - r_i: color component of f(x,y)
  - $\{T_1, T_2, \ldots, T_n\}$: a set of transformation or color mapping functions
  - n transformations, T_i, are combined to form T

6.5 Color Transformation

- For example,
  - If RGB color space is selected, then $n = 3$, and r_1, r_2, and r_3 denote the red, green, and blue components of the input image
  - If CMYK color space is chosen, then $n = 4$
  - If HIS color space is chosen, then $n = 3$

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

- **Color components**

FIGURE 6.30 A full-color image and its various color-space components. (Original image courtesy of Med-Data Interactive.)

6.5 Color Transformation

- For example,
  - Modify the intensity of the image:

$$g(x,y) = k\,f(x,y),\ \ 0 < k < 1$$

    - In the HSI color space, this mapping can be done with the simple transformation:

$$s_3 = k\,r_3$$

    - In the RGB color space, the RGB color mapping

$$s_i = k\,r_i,\ I = 1, 2, 3$$

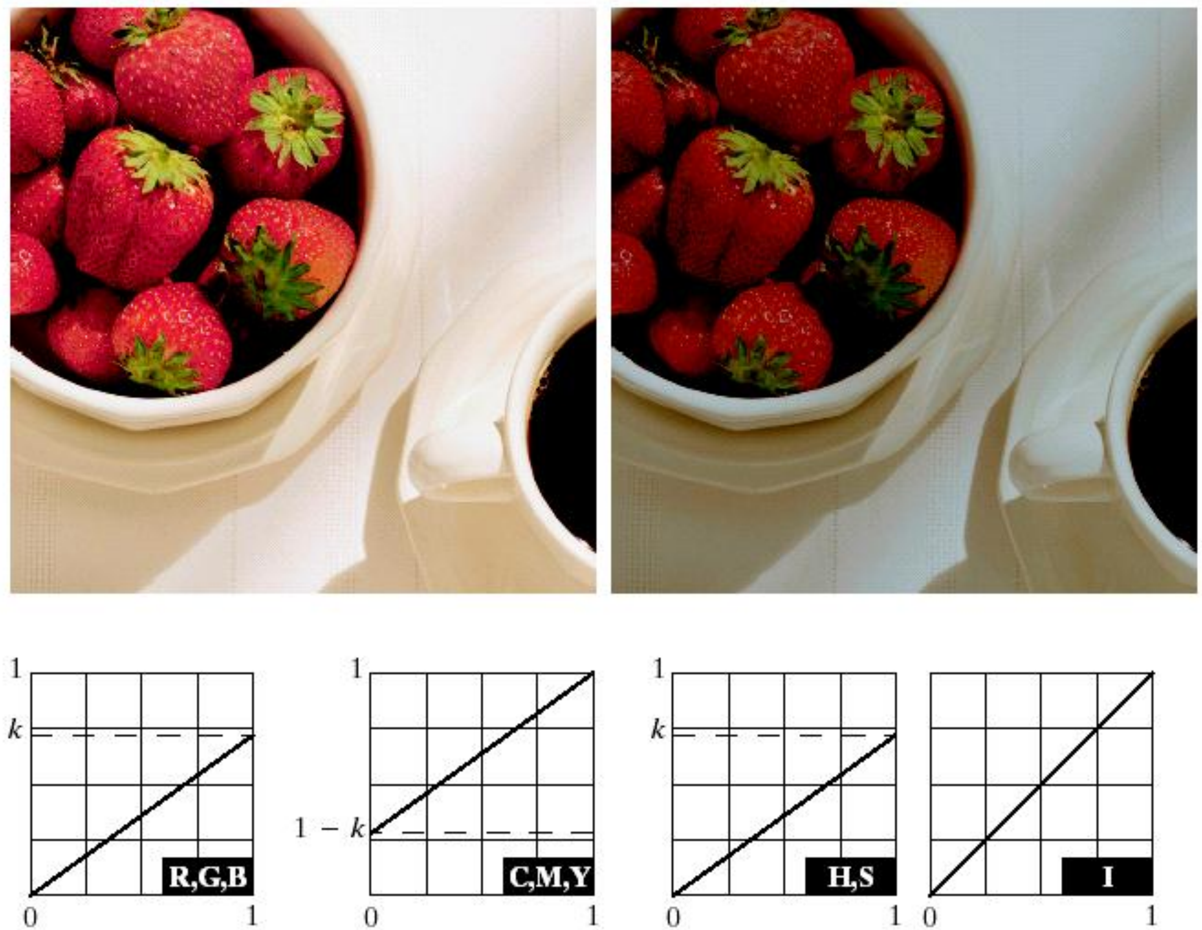
    - The CMY color space has s similar transformations

$$s_i = k\,r_i + (1 - k),\ \ i = 1, 2, 3$$

6.5 Color Transformation

a b
c d e

FIGURE 6.31 Adjusting the intensity of an image using color transformations. (a) Original image. (b) Result of decreasing its intensity by 30% (i.e., letting $k = 0.7$). (c)–(e) The required RGB, CMY, and HSI transformation functions. (Original image courtesy of MedData Interactive.)



6.5.2 Color complements

- **Color complements** are useful for enhancing details that is embedded in dark regions of a color image

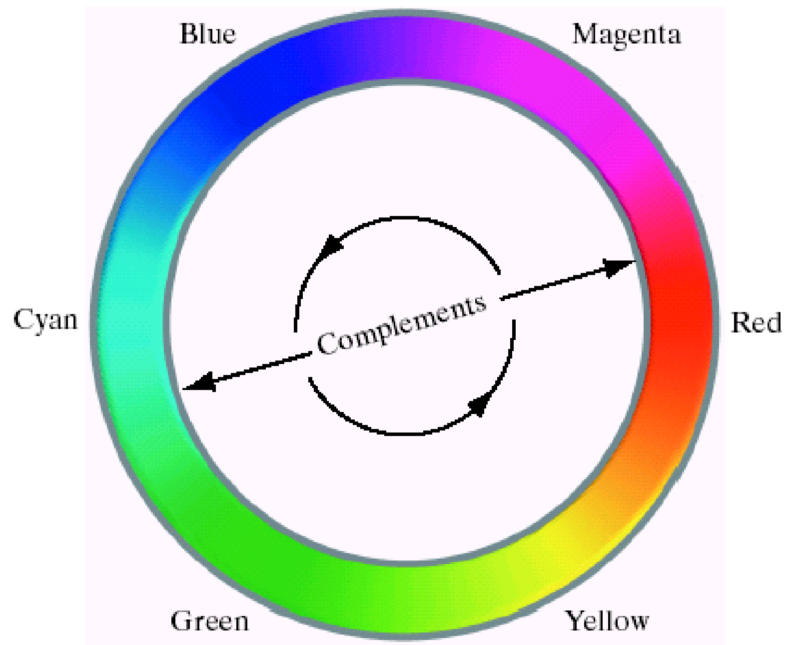
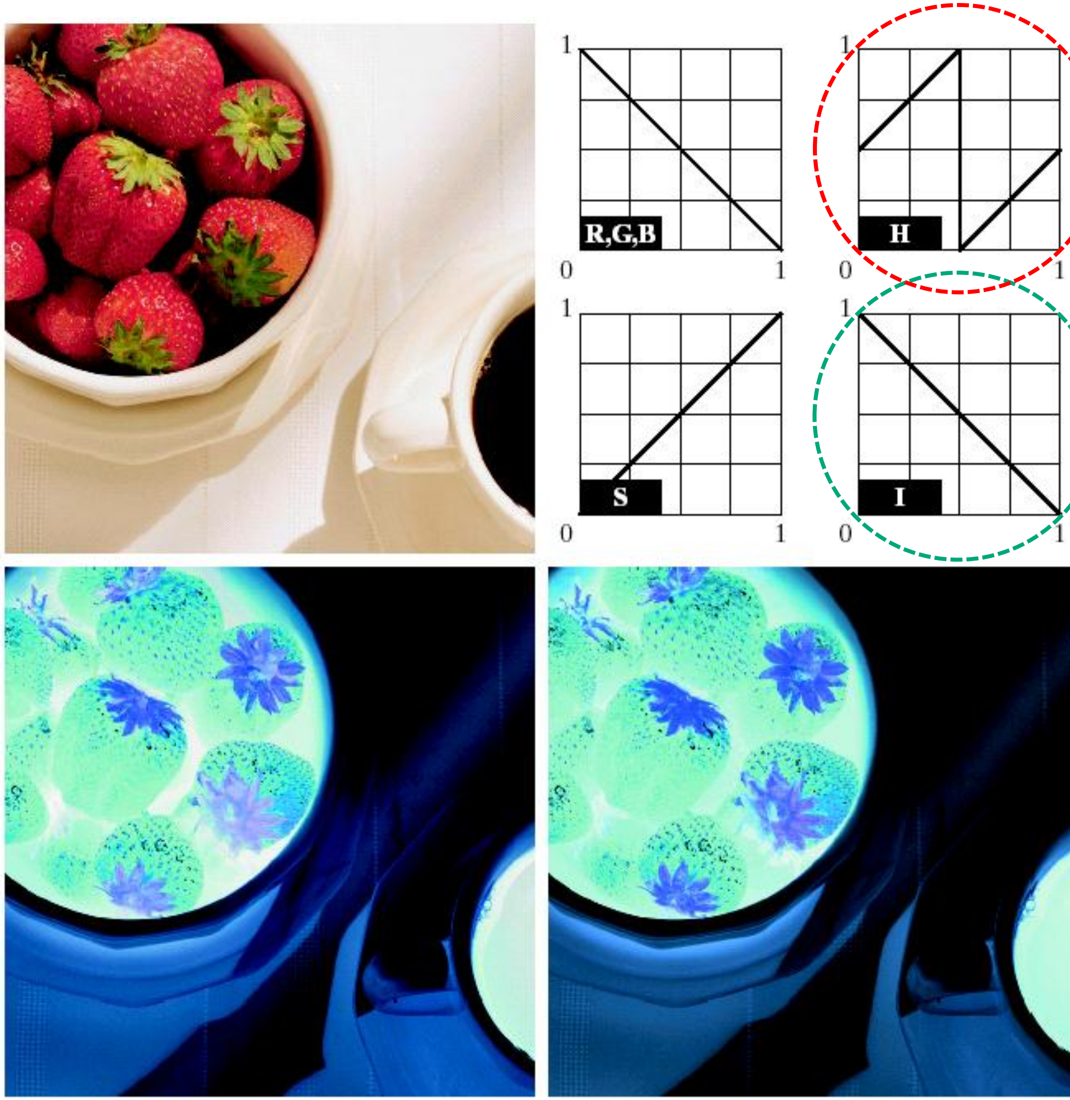


FIGURE 6.32 Complements on the color circle.

6.5.2 Color complements



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 Color Slicing

- Highlighting a specific range of colors in images
- Multidimensional color slicing
  - Hypercube segmentation: Ex. Fig 6.34

$$s_i = \begin{cases} 0.5, & \text{if } [|r_j - a_j| > W/2]_{1 \le j \le n} \\ r_i, & \text{otherwise} \end{cases}$$

  - Sphere segmentation: Ex. Fig 6.34

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

6.5.3 Color Slicing

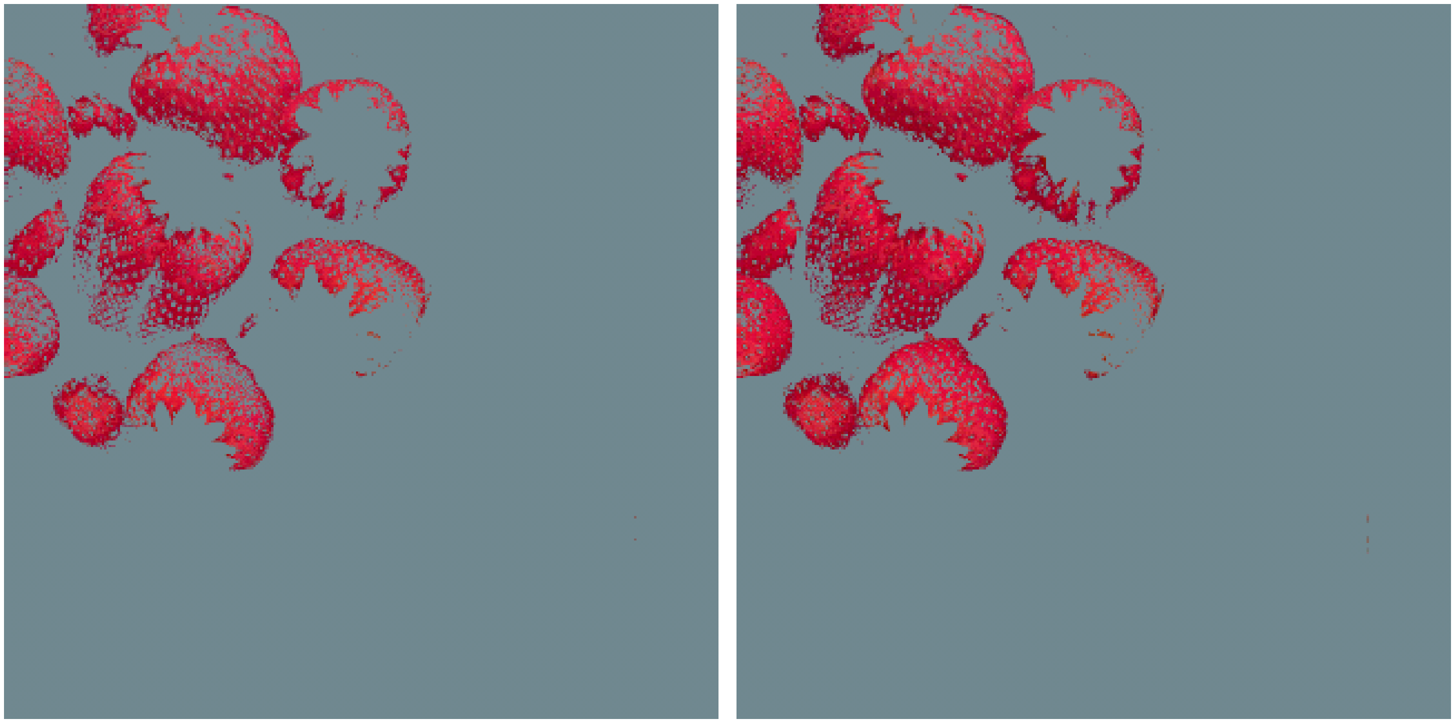


FIGURE 6.34 Color slicing transformations that detect (a) reds within an RGB cube of width $W = 0.2549$ centered at (0.6863, 0.1608, 0.1922), and (b) reds within an RGB sphere of radius 0.1765 centered at the same point. Pixels outside the cube and sphere were replaced by color (0.5, 0.5, 0.5).

6.5.4 Tone and Color Corrections

- Photo enhancement and color reproduction
- To maintain a high degree of color consistence between the monitors and the output devices
- To develop a device-independent color model that relates the color gamuts of the monitors and the output devices
- Choices for many color management systems: CIE $L^*a^*b^*$ (also called CIELAB)

6.5.4 Tone and Color Corrections

- CIE *L*a*b** color model:

$$L^* = 116h(\frac{Y}{Y_W}) - 16$$

$$a^* = 500[h(\frac{X}{X_W}) - h(\frac{Y}{Y_W})]$$

$$b^* = 200[h(\frac{Y}{Y_W}) - h(\frac{Z}{Z_W})]$$

$$h(q) = \begin{cases} \sqrt[3]{q}, q > 0.008856 \\ 7.787q + 16/116, q \le 0.008856 \end{cases}$$

X_W, Y_W, Z_W: reference white stimulus values

6.5.4 Tone and Color Corrections

- Properties of CIE *L*a*b** color model:
  - Colorimetric – colors perceived as matching are encoded identically
  - Perceptually uniform – color differences among various hues are perceived uniformly
  - Device independent

6.5.4 Tone and Color Corrections

- The tonal range (key type) of an image refers to its general distribution of color intensities
  - High-key images – most of the information concentrates at high (light) intensities
  - Low-key images – most of the information locates predominately at low intensities
  - Medium-key images – lie in between

6.5.4 Tone and Color Corrections

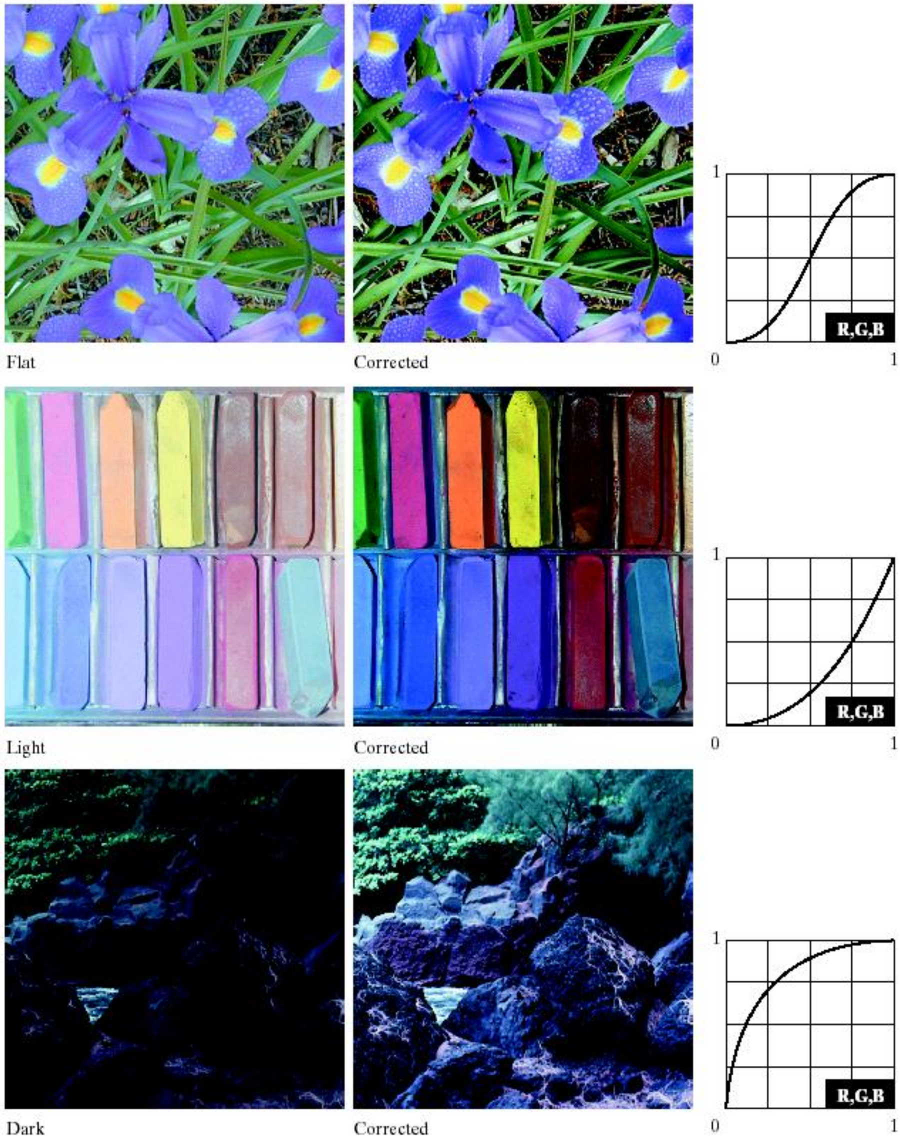


FIGURE 6.35 Tonal corrections for flat, light (high key), and dark (low key) color images. Adjusting the red, green, and blue components equally does not alter the image hues.

6.5.4 Tone and Color Corrections

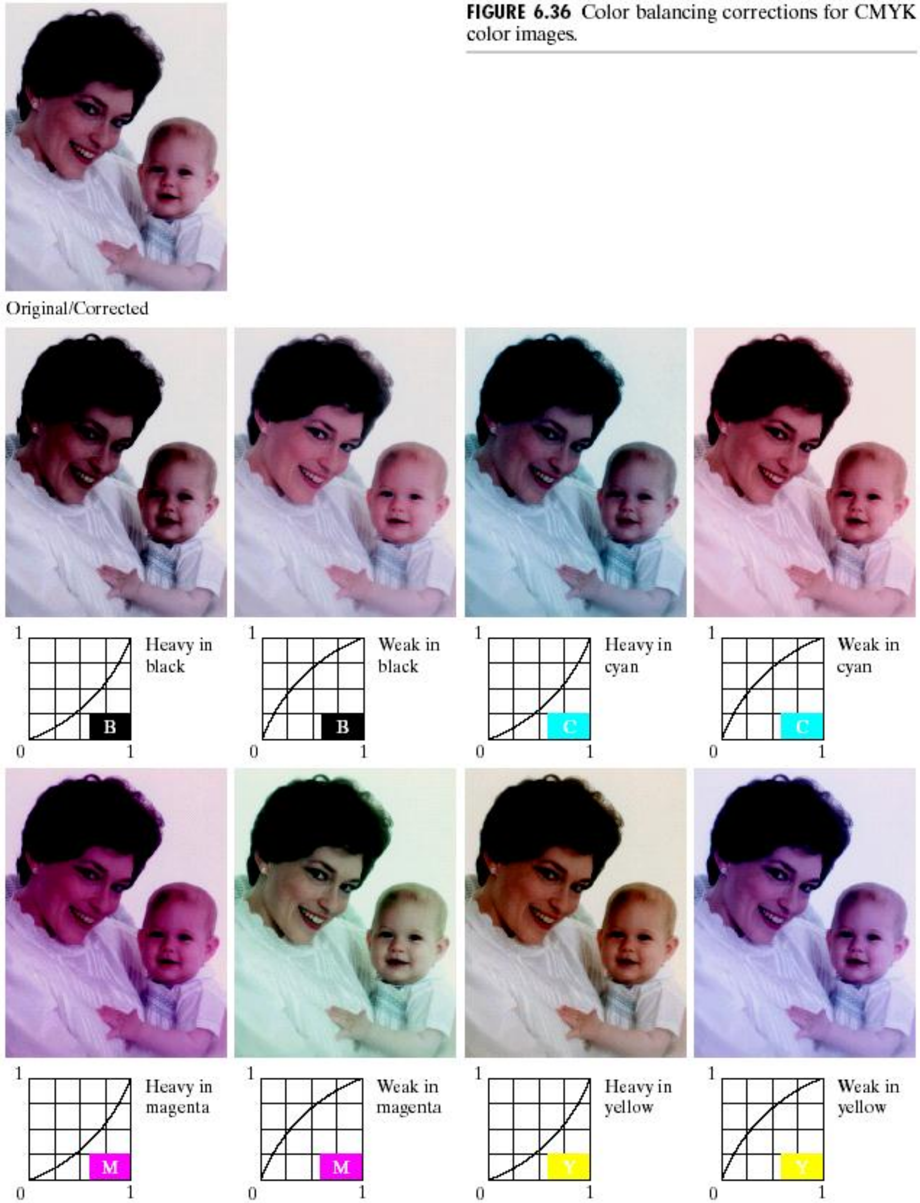


FIGURE 6.36 Color balancing corrections for CMYK color images.

6.5.5 Histogram Processing

- Histogram equalize the components of a color image independently results in erroneous color
- A more logical approach is to spread the color intensities uniformly, leaving the colors themselves (e.g., hues) unchanged

6.5.5 Histogram Processing

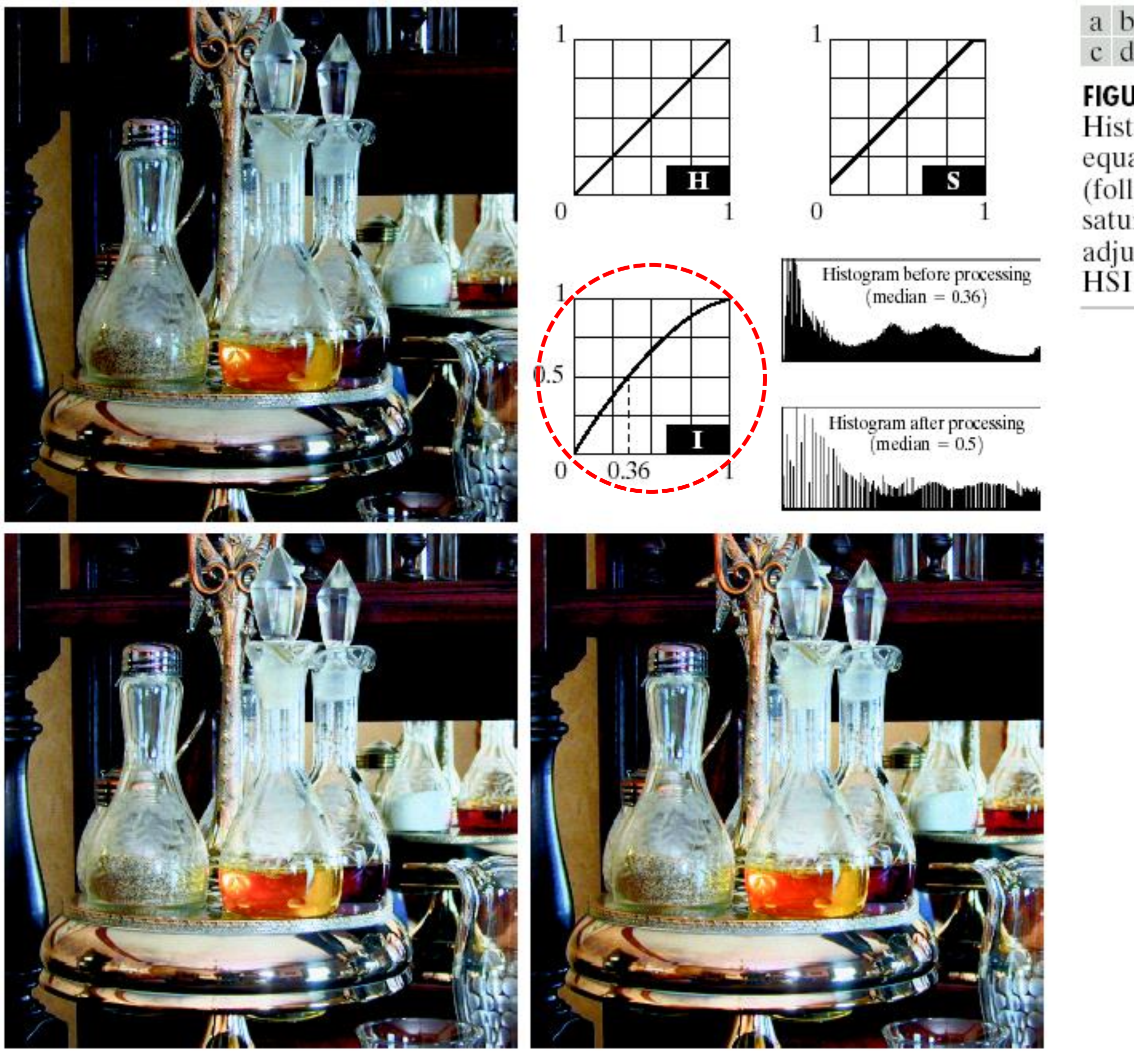


FIGURE 6.37 Histogram equalization (followed by saturation adjustment) in the HSI color space.

6.6 Smoothing and Sharpening

- Smoothing

$$\bar{\mathbf{c}}(x, y) = \frac{1}{K} \sum_{(x,y)\in S_{xy}} \mathbf{c}(x, y) = \begin{bmatrix} \frac{1}{K} \sum_{(x,y)\in S_{xy}} R(x, y) \\ \frac{1}{K} \sum_{(x,y)\in S_{xy}} G(x, y) \\ \frac{1}{K} \sum_{(x,y)\in S_{xy}} B(x, y) \end{bmatrix}$$

- Ex. Fig 6.38 ~ Fig. 6.41

6.6 Smoothing and Sharpening

a b
c d

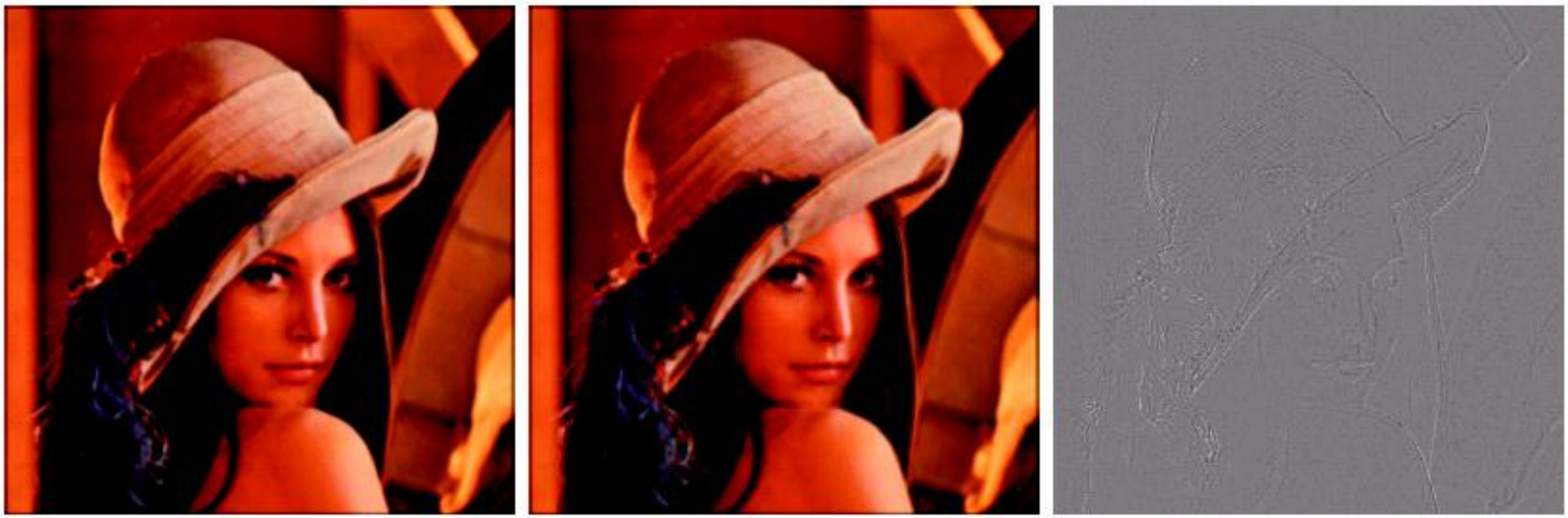
FIGURE 6.38
(a) RGB image.
(b) Red component image.
(c) Green component.
(d) Blue component.

6.6 Smoothing and Sharpening

a b c

FIGURE 6.39 HSI components of the RGB color image in Fig. 6.38(a). (a) Hue. (b) Saturation. (c) Intensity.

6.6 Smoothing and Sharpening



a b c

FIGURE 6.40 Image smoothing with a 5 × 5 averaging mask. (a) Result of processing each RGB component image. (b) Result of processing the intensity component of the HSI image and converting to RGB. (c) Difference between the two results.

6.6.2 Color sharpening

- Laplacian enhancement

$$\nabla^2[\mathbf{c}(x, y)] = \begin{bmatrix} \nabla^2 R(x, y) \\ \nabla^2 G(x, y) \\ \nabla^2 B(x, y) \end{bmatrix}$$

- Ex. Fig. 6.41

6.6.2 Color sharpening

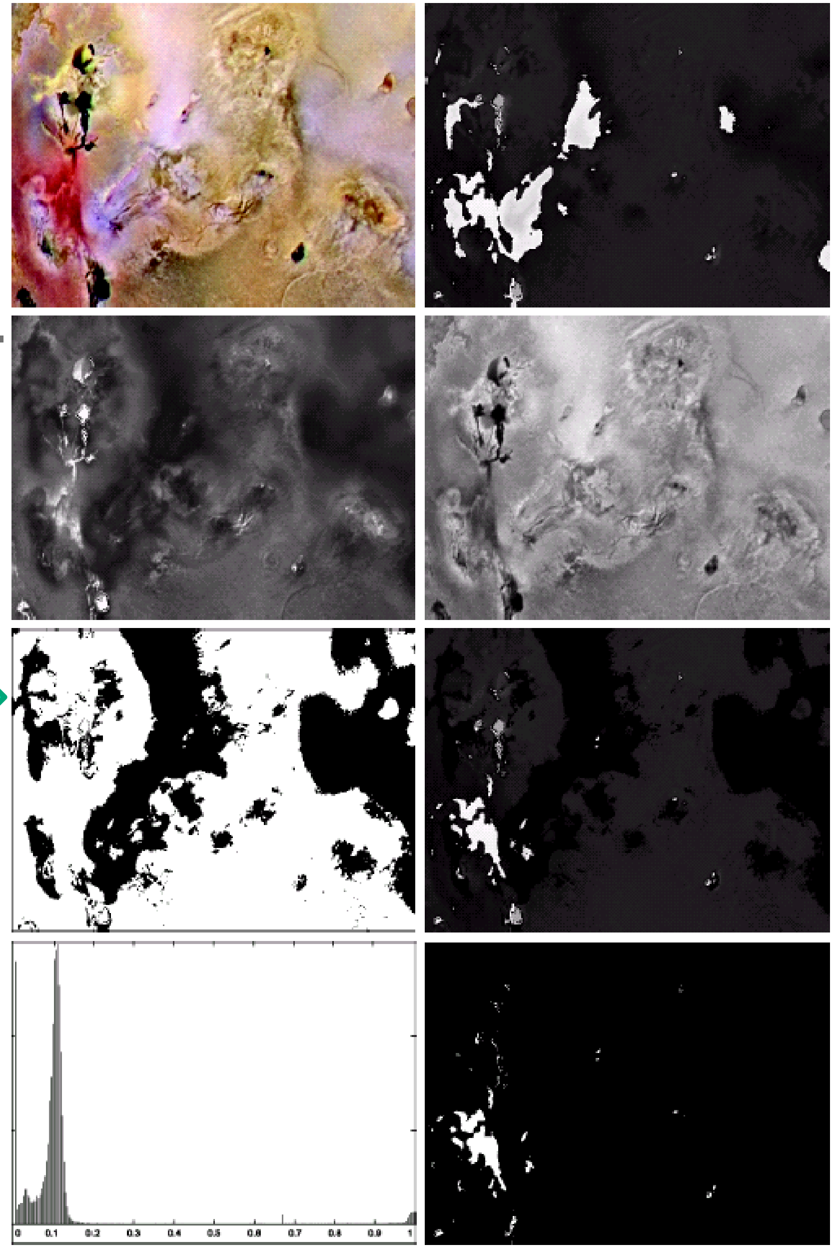
a b c

FIGURE 6.41 Image sharpening with the Laplacian. (a) Result of processing each RGB channel. (b) Result of processing the intensity component and converting to RGB. (c) Difference between the two results.

6.7 Color Segmentation

- Segmentation in HSI color space
  - Segmentation is implemented mainly in the hue image
  - Saturation image is used as masking image in order to isolate the regions with the similar hue value
- Ex. Fig 6.42

T = 10% × max



a b
c d
e f
g h

FIGURE 6.42 Image segmentation in HSI space. (a) Original. (b) Hue. (c) Saturation. (d) Intensity. (e) Binary saturation mask (black = 0). (f) Product of (b) and (e). (g) Histogram of (f). (h) Segmentation of red components in (a).

6.7.2 Segmentation in RGB Vector Space

- Objective– classify each RGB pixel in a given image as having a color in a specified range or not
- Let **z** denote an arbitrary point in RGB space, then **z** is similar to **a** if the distance between them is less than a specified threshold, D_0
- The Euclidean distance between **z** and **a**:

$$D(\mathbf{z}, \mathbf{a}) = \|\mathbf{z} - \mathbf{a}\| = [(\mathbf{z} - \mathbf{a})^T (\mathbf{z} - \mathbf{a})]^{\frac{1}{2}}$$

$$= [(z_R - a_R)^2 + (z_G - a_G)^2 + (z_B - a_B)^2]^{\frac{1}{2}}$$

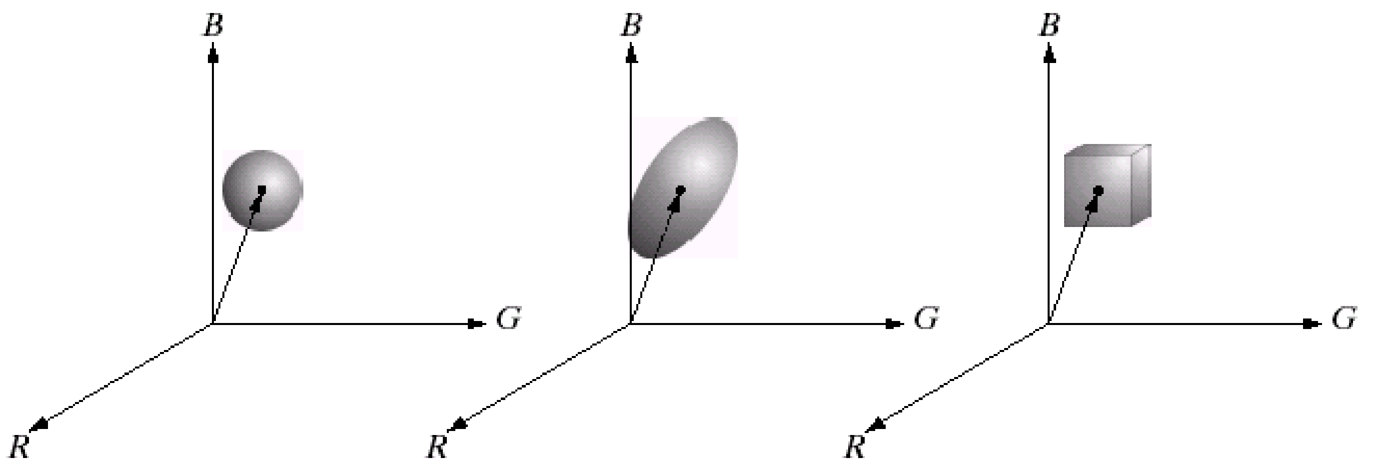
  - The locus of points such that $D(\mathbf{z}, \mathbf{a}) \leq D_0$ is a solid sphere of radius D_0

6.7.2 Segmentation in RGB Vector Space

- General distance measure:

$$D(\mathbf{z}, \mathbf{a}) \leq [(\mathbf{z} - \mathbf{a})^T \mathbf{C}^{-1} (\mathbf{z} - \mathbf{a})]^{\frac{1}{2}}$$

  - **C** is the covariance matrix of the samples representative of the color we wish to segment



a b c

FIGURE 6.43 Three approaches for enclosing data regions for RGB vector segmentation.

6.7.2 Segmentation in RGB Vector Space

- Fig. 6.44 illustrates the segmentation process

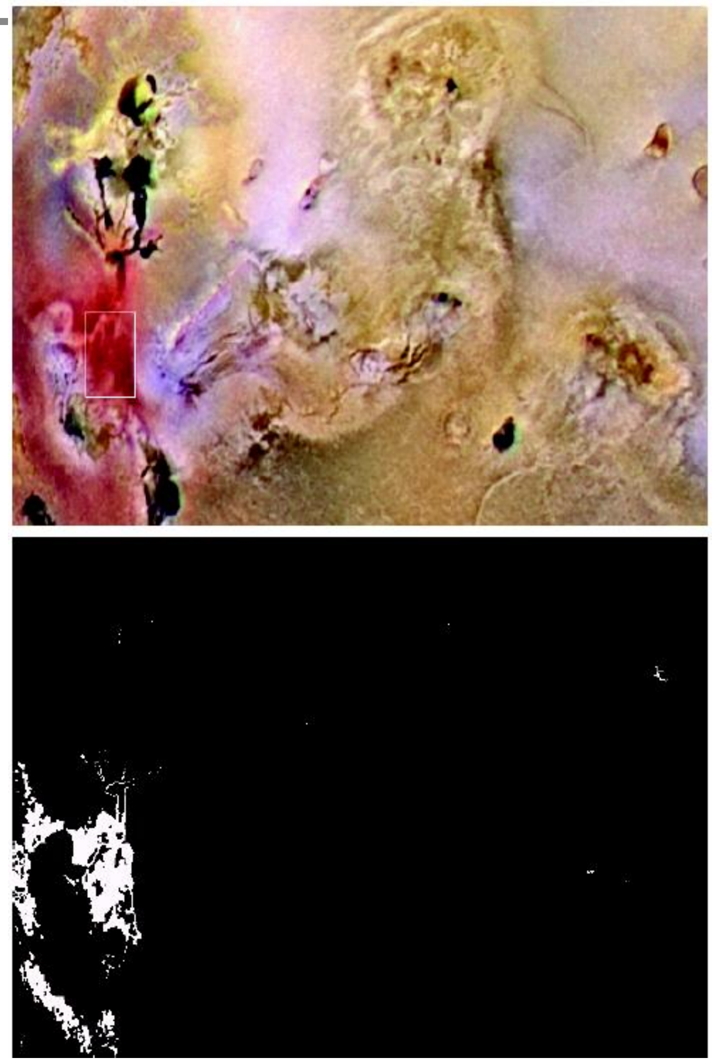


FIGURE 6.44 Segmentation in RGB space. (a) Original image with colors of interest shown enclosed by a rectangle. (b) Result of segmentation in RGB vector space. Compare with Fig. 6.42(h).

6.7.3 Color edge detection

- Approaches for color edge detection
  - Computing edges on an individual-image basis
  - Computing edges directly in color vector space

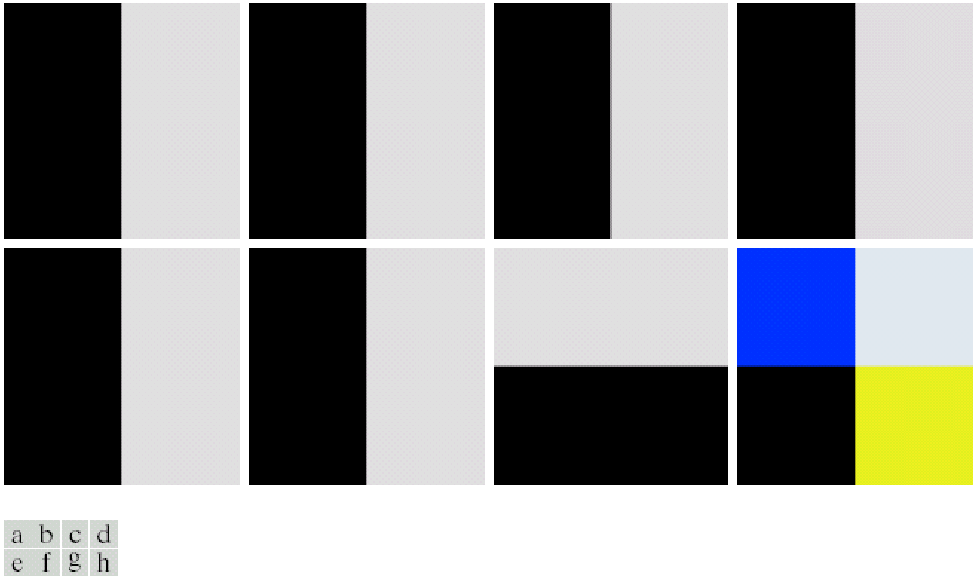


FIGURE 6.45 (a)–(c) R, G, and B component images and (d) resulting RGB color image. (f)–(g) R, G, and B component images and (h) resulting RGB color image.

6.7.3 Color edge detection

- The gradient is a vector pointing in the direction of maximum rate of change of a function *f* at point (x, y)

$$\mathbf{u} = \frac{\partial R}{\partial x}\mathbf{r} + \frac{\partial G}{\partial x}\mathbf{g} + \frac{\partial B}{\partial x}\mathbf{b}$$

$$\mathbf{v} = \frac{\partial R}{\partial y}\mathbf{r} + \frac{\partial G}{\partial y}\mathbf{g} + \frac{\partial B}{\partial y}\mathbf{b}$$

$$g_{xx} = \mathbf{u}\cdot\mathbf{u} = \mathbf{u}^{\mathrm{T}}\mathbf{u} = \left|\frac{\partial R}{\partial x}\right|^2 + \left|\frac{\partial G}{\partial x}\right|^2 + \left|\frac{\partial B}{\partial x}\right|^2$$

$$g_{yy} = \mathbf{v}\cdot\mathbf{v} = \mathbf{v}^{\mathrm{T}}\mathbf{v} = \left|\frac{\partial R}{\partial y}\right|^2 + \left|\frac{\partial G}{\partial y}\right|^2 + \left|\frac{\partial B}{\partial y}\right|^2$$

$$g_{xy} = \mathbf{u}\cdot\mathbf{v} = \mathbf{u}^{\mathrm{T}}\mathbf{v} = \frac{\partial R}{\partial x}\frac{\partial R}{\partial y} + \frac{\partial G}{\partial x}\frac{\partial G}{\partial y} + \frac{\partial B}{\partial x}\frac{\partial B}{\partial y}$$

6.7.3 Color edge detection

- The direction of maximum rate of change of **c**(x, y) is given by the angle (proposed by Di Zenzo [1986])

$$\theta = \frac{1}{2}\tan^{-1}\left[\frac{2g_{xy}}{g_{xx} - g_{yy}}\right]$$

- The value of maximum rate of change of **c**(x, y) is given by

$$F(\theta) = \left\{\frac{1}{2}[(g_{xx} + g_{yy}) + (g_{xx} - g_{yy})\cos 2\theta + 2g_{xy}\sin 2\theta]\right\}^{\frac{1}{2}}$$

6.7.3 Color edge detection

FIGURE 6.46 (a) RGB image. (b) Gradient computed in RGB color vector space. (c) Gradients computed on a per-image basis and then added. (d) Difference between (b) and (c).

6.7.3 Color edge detection

a b c

FIGURE 6.47 Component gradient images of the color image in Fig. 6.46. (a) Red component, (b) green component, and (c) blue component. These three images were added and scaled to produce the image in Fig. 6.46(c).

6.8 Noise in Color Images

- Noise in RGB
- Noise in HSI

6.8 Noise in Color Images

a b
c d

FIGURE 6.48 (a)–(c) Red, green, and blue component images corrupted by additive Gaussian noise of mean 0 and variance 800. (d) Resulting RGB image. [Compare (d) with Fig. 6.46(a).]

6.8 Noise in Color Images

a b c

FIGURE 6.49 HSI components of the noisy color image in Fig. 6.48(d). (a) Hue. (b) Saturation. (c) Intensity.

6.8 Noise in Color Images

a b
c d

FIGURE 6.50
(a) RGB image with green plane corrupted by salt-and-pepper noise.
(b) Hue component of HSI image.
(c) Saturation component.
(d) Intensity component.

6.9 Color Image Compression

- **Compression** – the process of reducing or eliminating redundant and/or irrelevant data

6.9 Color Image Compression

a b
c d

FIGURE 6.51 Color image compression. (a) Original RGB image. (b) Result of compressing and decompressing the image in (a).

CR = 230