GRVM

Cores

Judith Kelner
Eduardo Albuquerque

Centro de Informática U·F·P·E

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VIRTUS IMPAVIDA UFPE

Fundamentos

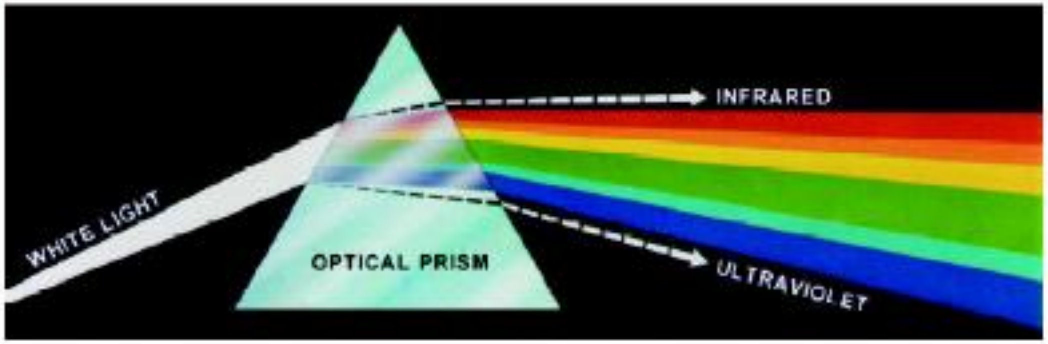


FIGURE 6.1 Color spectrum seen by passing white light through a prism. (Courtesy of the General Electric Co., Lamp Business Division.)

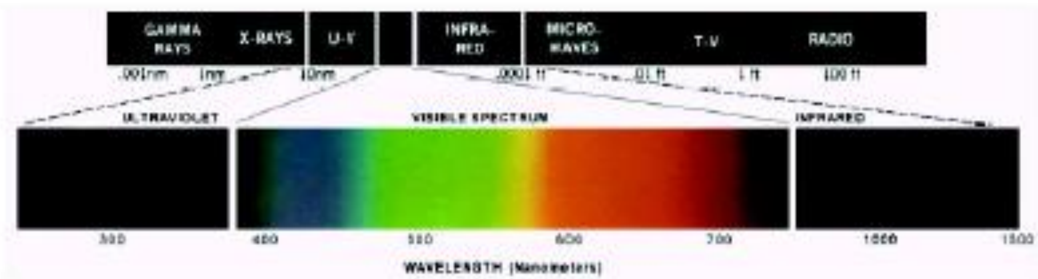


FIGURE 6.2 Wavelengths comprising the visible range of the electromagnetic spectrum. (Courtesy of the General Electric Co., Lamp Business Division.)

- O fenômeno fisiopsicológico de percepção de cores pelo ser humana não é completamente compreendido, porém a natureza física das cores pode ser explicadas formalmente.
- Em 1666, Newton descobriu que um feixe de luz solar é decomposta ao passar no prisma.
- As cores que percebemos num objeto são determinadas pela natureza da luz refletida.
- A luz visível e composta de uma banda de freqüências relativamente estreita no espectro eletromágnetico.
- Luz acromática (sem cores), seu único atributo é a sua intensidade (quantidade). Ex: tv preto e branco, imagens em tons de cinza.
- Luz cromática consiste na região do espectro eletromagnético desde aproximadamente 400 até 700 nm. A qualidade da luz cromática e descrita por 3 valores básicos: radiância, luminância e brilho.

Absorção de Luzes

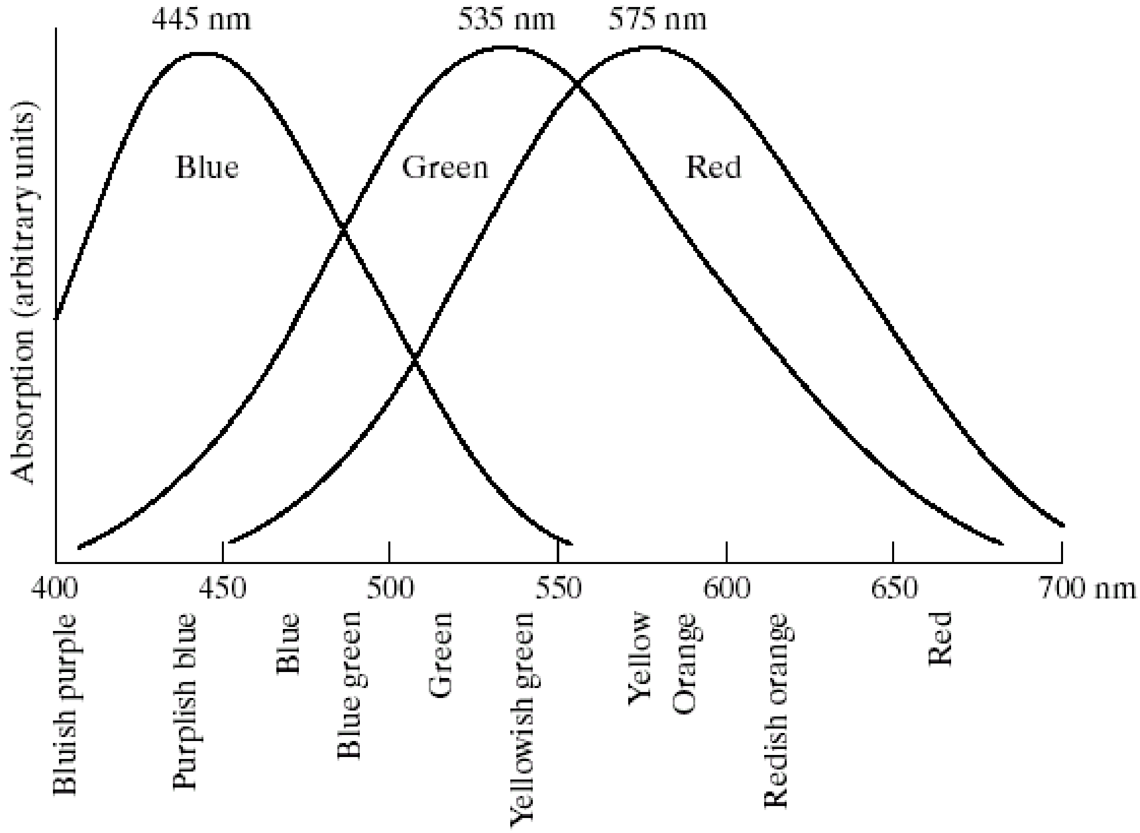
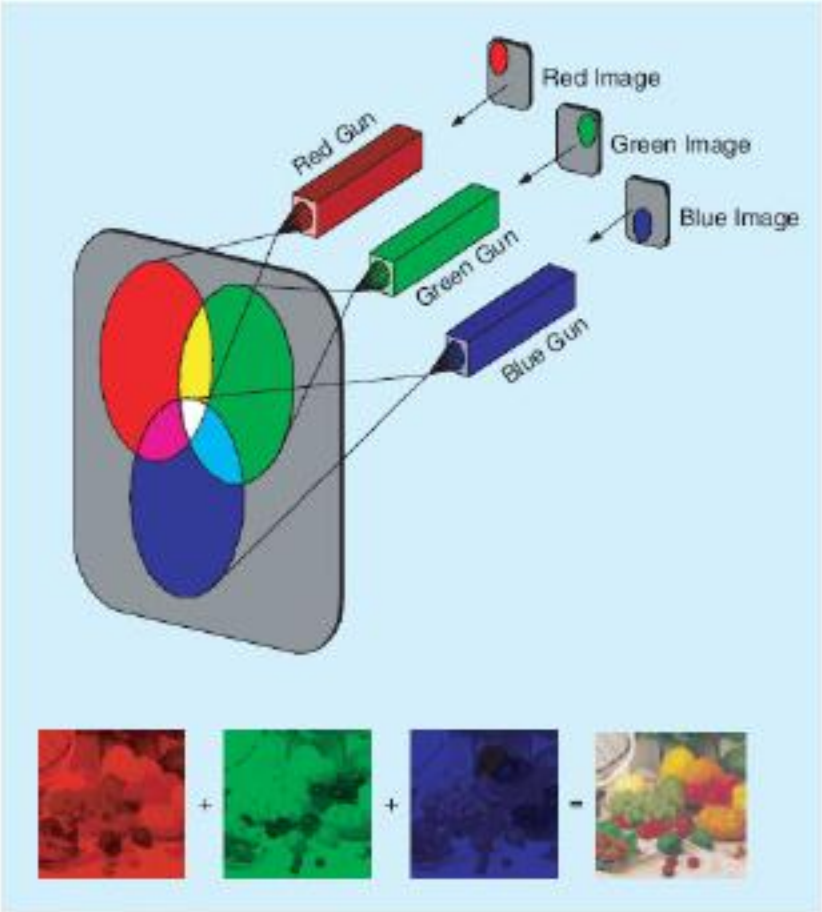


FIGURE 6.3 Absorption of light by the red, green, and blue cones in the human eye as a function of wavelength.

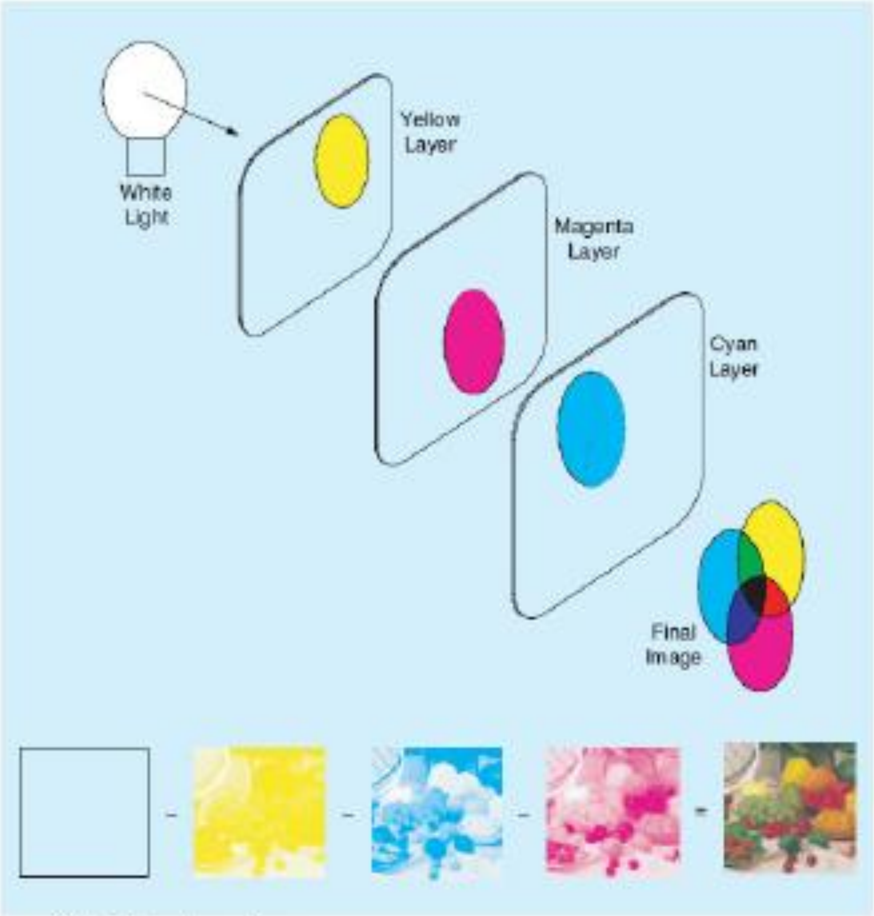
Espaços de cores

- Imagem mono cromática requer apenas um número para indicar o brilho ou *luminância* de cada amostra espacial
- Imagem colorida requer pelo menos 3 números por pixel
  - O método escolhido para representar brilho (*luminância* ou luma) e cor é descrito como um espaço de cor

Sistemas Aditivo e Subtrativo

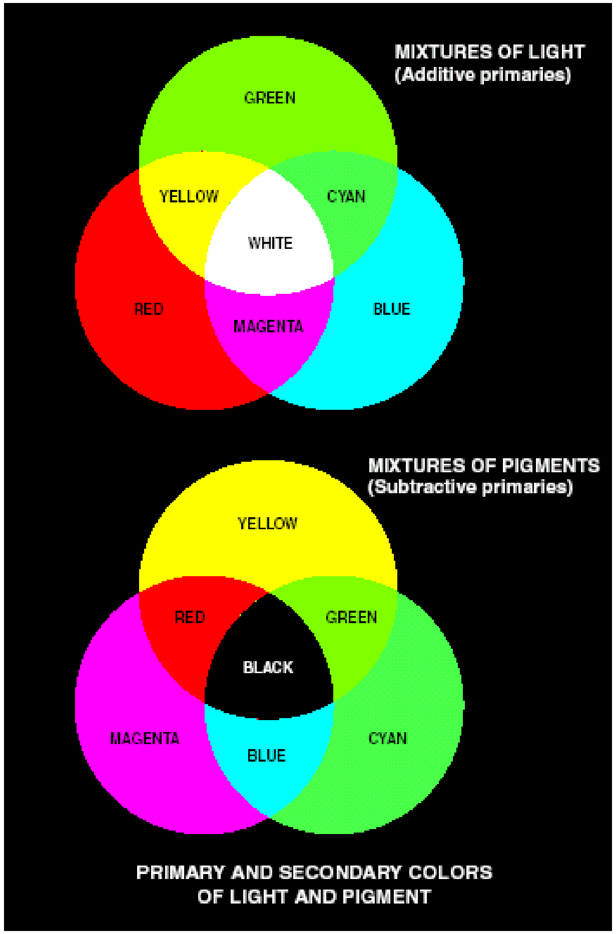


Additive color system.



Subtractive color system.

Luzes e Pigmentos



a
b

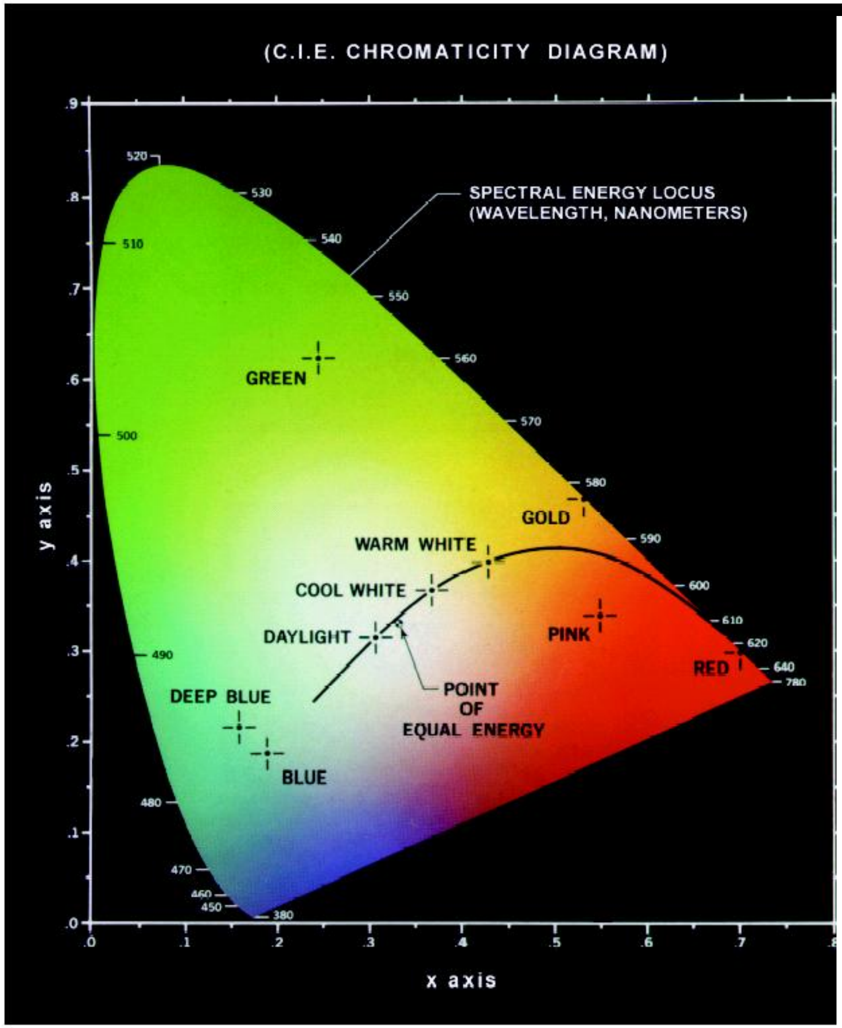
FIGURE 6.4 Primary and secondary colors of light and pigments. (Courtesy of the General Electric Co., Lamp Business Division.)

- As cores primárias (modelo aditivo) podem ser adcionados para produzir as cores secundárias: magneta, ciano e amarelo. A mistura das três cores primárias, ou uma secundária com sua cor primária oposta, em intensidades corretas produz a luz branca.

- Cor primária de pigmentos ou corantes (modelo subtrativo) , é definida como sendo aquela que subtrai ou absorve uma cor primária da luz e reflete ou transmite as outras duas

Diagrama de Cromacidade

FIGURE 6.5 Chromaticity diagram. (Courtesy of the General Electric Co., Lamp Business Division.)



- As características usadas para distinguir um cor da outras são brilho, matiz, e saturação.
- **Brilho** incorpora a noção cromática de intensidade.
- **Matiz** é um atributo associado com o comprimento de onda dominante em uma mistura de ondas de luz. O matiz representa a cor dominante como percebido por um observador.
- **Saturação** refere-se à pureza relativa ou quantidade de luz branca misturada com um matiz.
- Cromaticidade é definido como a matiz e a saturação quantdo tomadas juntamente.
- Diagrama CIE codifica a percentagem das primárias usadas para gerar cores (componente azul é obtida a partir das outras duas)

Cores

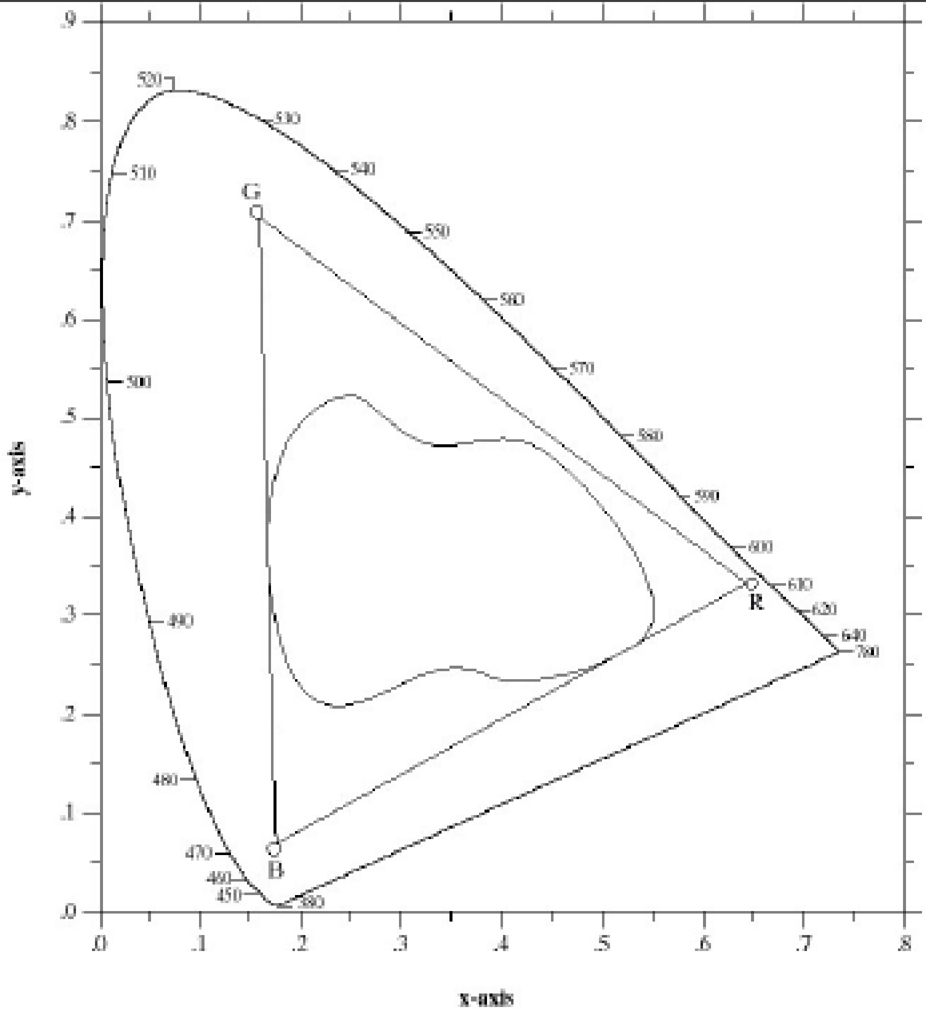


FIGURE 6.6 Typical color gamut of color monitors (triangle) and color printing devices (irregular region).

- Representação triestímulo tem valores: X – Vermelho; Y – Verde; Z – Azul
- Coeficientes tricromáticos:

$$x = \frac{X}{X+Y+Z}$$

$$y = \frac{Y}{X+Y+Z}$$

$$z = \frac{Z}{X+Y+Z}$$

$$x + y + z = 1$$

- O triângulo mostra a uma faixa típica da gama de cores (gamutes de cor) produzida por monitores RGB.
- A região irregular representa a região de cores das impressoras coloridas atuais.

Gamut de cores

- É um subconjunto completo de cores
  - Subconjunto de cores que podem ser apuradamente representadas em uma dada circunstância
    - Dentro de um dado espaço de cores
    - Por um dispositivo de saída
  - Conjunto completo de cores de uma imagem um um dado instante
    - Digitalizar um fotografia, converter uma imagem para um espaço de cores diferente ou transferi-la para um certo meio, usando um dispositivo específico, geralmente altera seu gamut (no sentido que algumas cores do original são perdidas no processo.

Gamut de cores

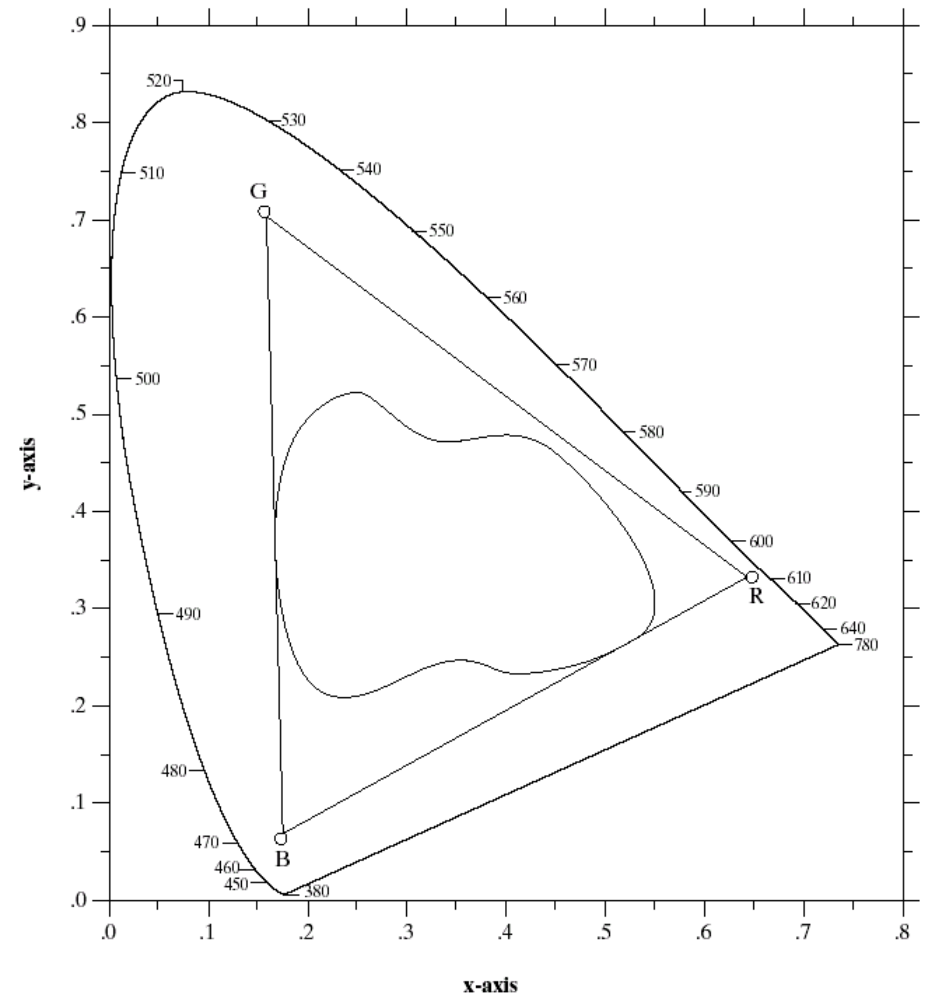
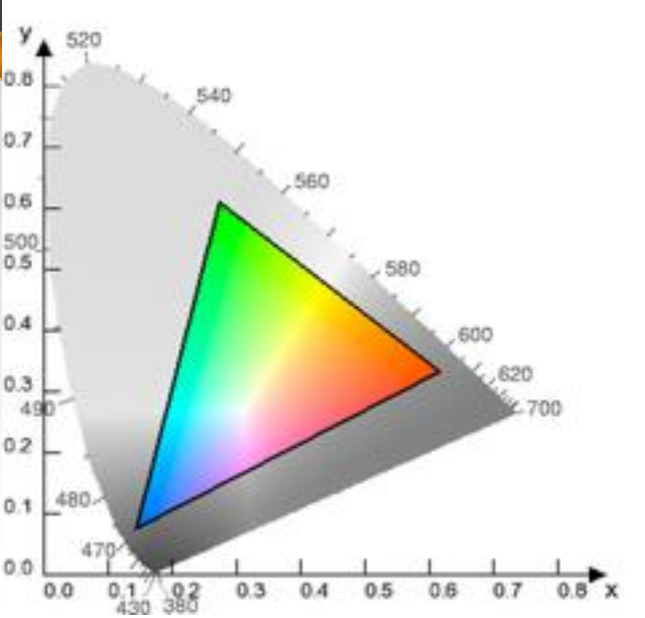


FIGURE 6.6 Typical color gamut of color monitors (triangle) and color printing devices (irregular region).



Um monitor não cobre todo espaço de cores.

Os cantos do triângulo são as primárias para o gamut

No caso de um CRT, dependem da capacidade de emissão do fósforo do monitor

Comparação de dispositivos (fonte: Wikipedia)

- Photographic film is one of the best systems available for detecting and reproducing color. Movie goers are familiar with the difference in color quality between the film projections seen in theaters and the home video versions. This is because the color gamut of film far exceeds that of television.

- Laser light shows use lasers to produce very nearly monochromatic light, allowing colors far more saturated than those produced by other systems. However, mixing hues to produce less saturated colors is difficult. In addition, such systems are complex, expensive, and ill-suited to general video display.

- CRT and similar video displays have a roughly triangular color gamut which covers a significant portion of the visible color space. In CRTs, the limitations are due to the phosphors in the screen which produce red, green, and blue light. Besides the limitations of the device itself, for displaying realistic images, such displays rely on the quality of color sensors, such as those in digital cameras and scanners. Sony has recently introduced a four-color (RGB plus "emerald") color sensor system which may eventually lead to high end video displays with an even larger color gamut. How practical this is remains to be seen.

Comparação de dispositivos (fonte: Wikipedia)

- Liquid crystal display (LCD) screens filter the light emitted by a backlight. The gamut of an LCD screen is therefore limited to the emitted spectrum of the backlight. Typical LCD screens use fluorescent bulbs for backlights, and have a gamut much smaller than CRT screens. LCD Screens with certain LED backlights yield a more comprehensive gamut than CRTs.

- Television uses a CRT display (usually), but does not take full advantage of its color display properties, due to the limitations of broadcasting. HDTV is far better, but still somewhat less than, for example, computer displays using the same display technology.

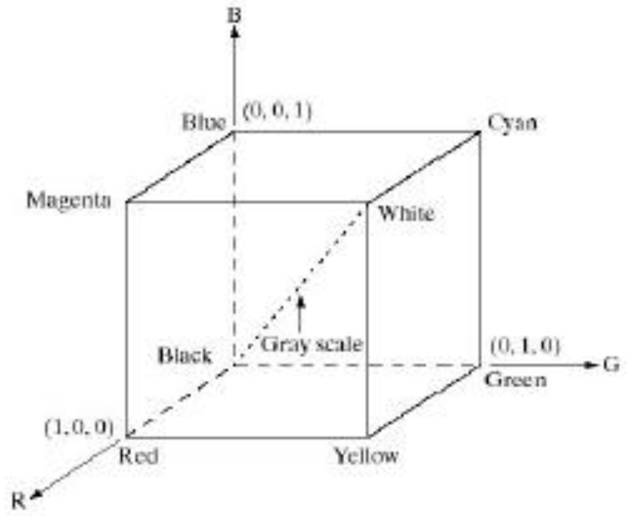
- Paint mixing, both artistic and for commercial applications, achieves a reasonably large color gamut by starting with a larger palette than the red, green, and blue of CRTs or cyan, magenta, and yellow of printing. Paint may reproduce some highly saturated colors that can not be reproduced well by CRTs (particularly violet), but overall the color gamut is smaller.

Comparação de dispositivos
(fonte: Wikipedia)

- Printing typically uses the CMYK color space (cyan, magenta, yellow, and black).
  - A very few printing processes do not include black; however, those processes are poor at representing low saturation, low intensity colors.
  - Efforts have been made to expand the gamut of the printing process by adding inks of non-primary colors; these are typically orange and green (see Hexachrome) or light cyan and light magenta. Spot color inks of a very specific color are also sometimes used.
- A monochrome display's color gamut is a one-dimensional curve in color space.

Cubo de cores RGB

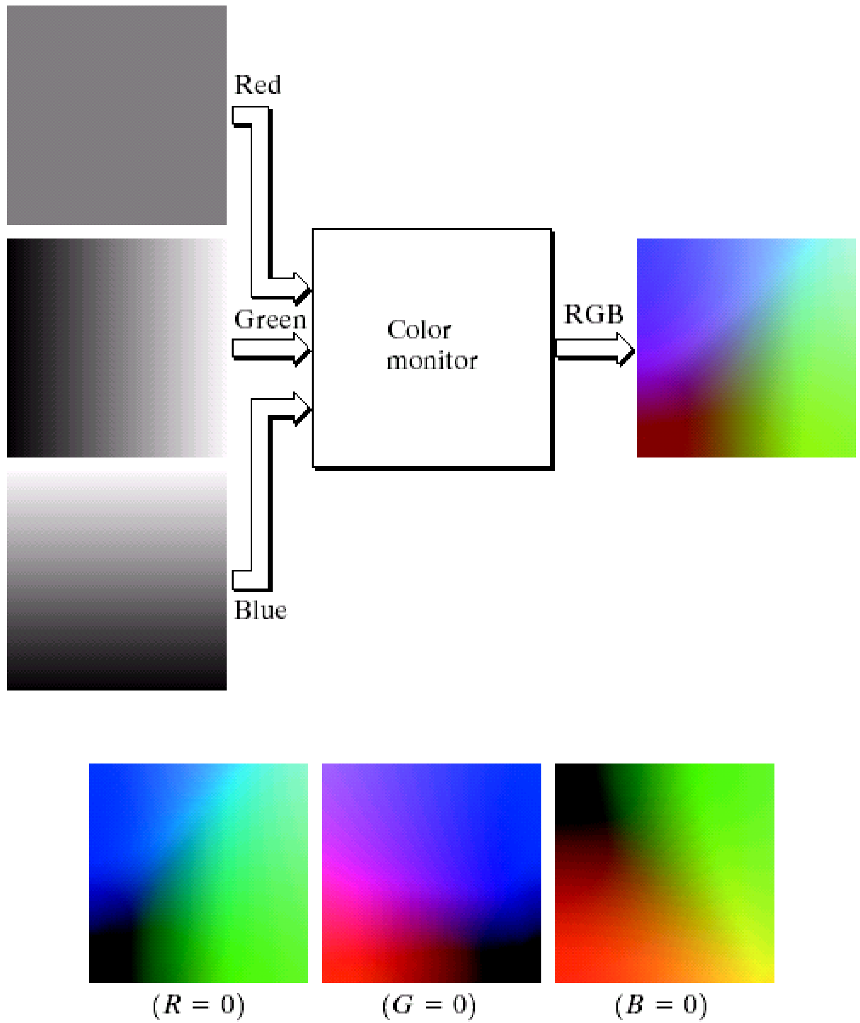
FIGURE 6.7 Schematic of the RGB color cube. Points along the main diagonal have gray values, from black at the origin to white at point (1, 1, 1).



- RGB é utilizado na maioria das vezes em modelos orientados para hardwares como monitores coloridos e câmeras de vídeo.
- A escala de cinza é representada pela diagonal do cubo.
- A quantificação determina a profundidade da cor (*color depth*). Uma imagem full-color é representada por 24 bits (22^{24} = 16.777.216 cores).

FIGURE 6.8 RGB 24-bit color cube.

Gerando uma imagem colorida



a
b

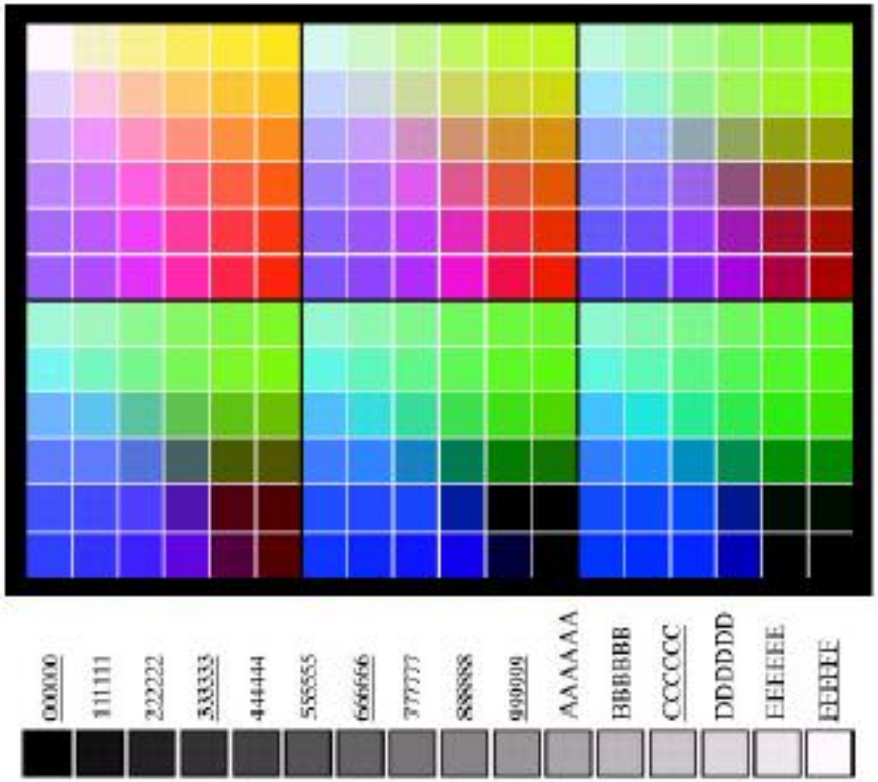
FIGURE 6.9 (a) Generating the RGB image of the cross-sectional color plane $(127, G, B)$. (b) The three hidden surface planes in the color cube of Fig. 6.8.

CoresSeguras

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.

- Devido as capacidades diferentes dos monitores, definui-se um conjunto de cores RGB seguras (safe RGB colors ou safe Web colors ou safe browser colors)
- As 216 cores RGB seguras sãomostradas ao lado



a
b

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).

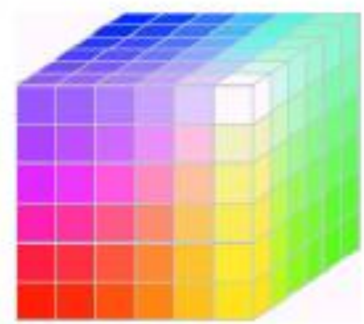


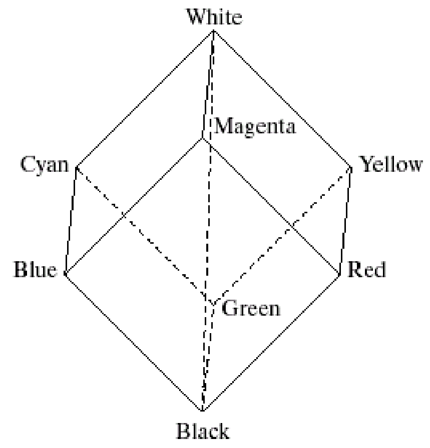
FIGURE 6.11 The RGB safe-color cube.

Modelo HSI (Hue Saturation Intensity)

- Hue: atributo da cor
- Saturation: pureza da cor
- Intensity: “briho”

- O Sistema Visual Humano (SVH) é muito mais sensível ao brilho que cores
- Sistemas como o RGB e CMY não são adequados para a representação de cores do SVH
- HIS separa as informações de intensidade das cromáticas

Relação entre RGB e HSI



a b

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

HSI

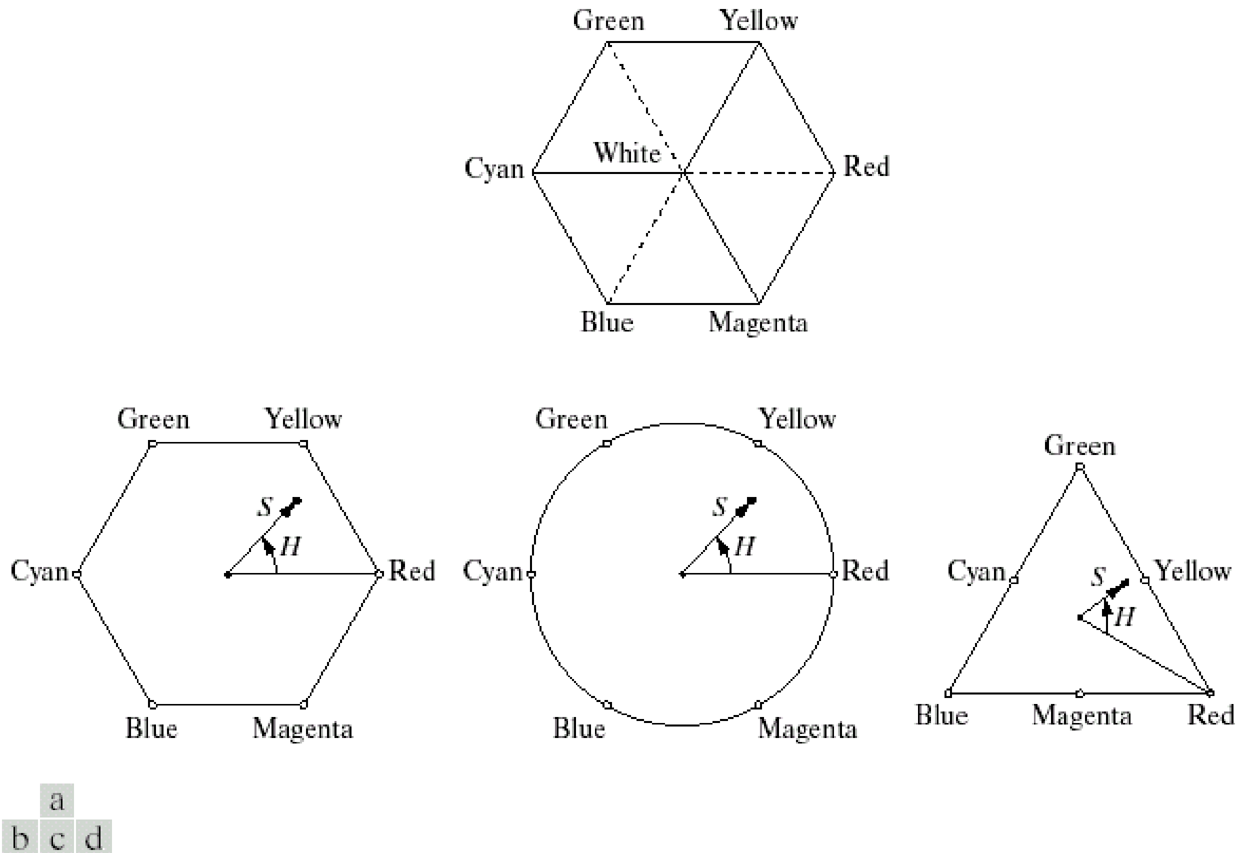
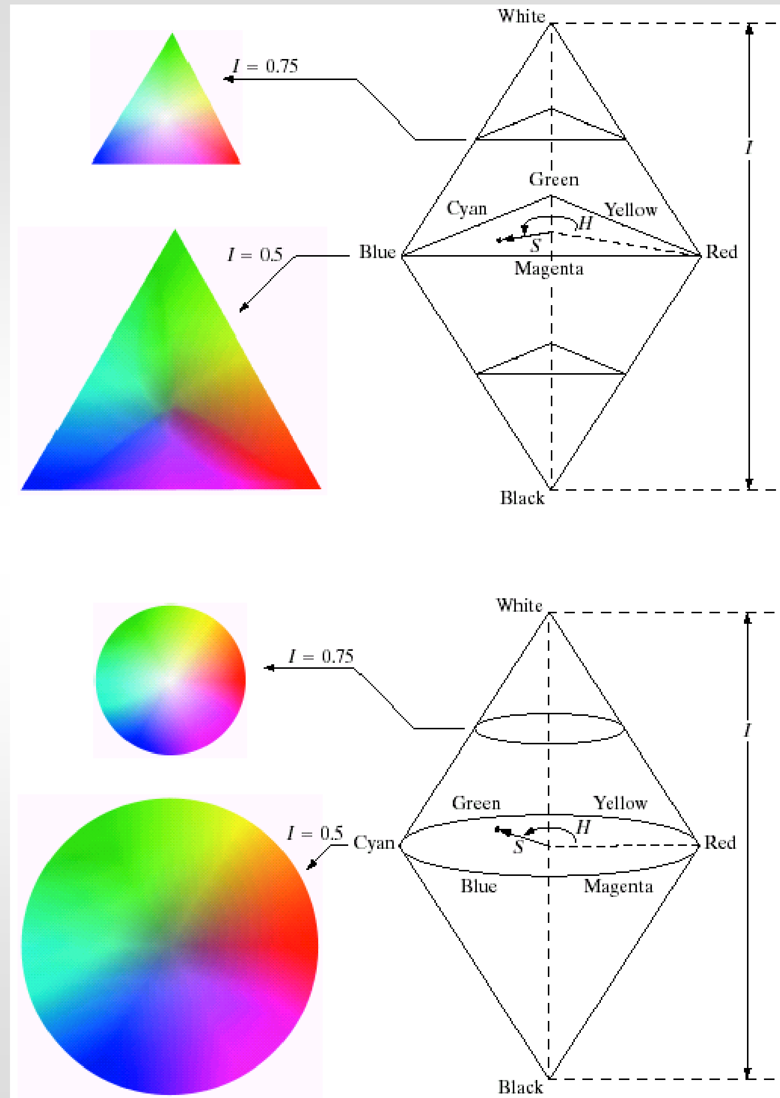


FIGURE 6.13 Hue and saturation in the HSI color model. The dot is an arbitrary color point. The angle from the red axis gives the hue, and the length of the vector is the saturation. The intensity of all colors in any of these planes is given by the position of the plane on the vertical intensity axis.

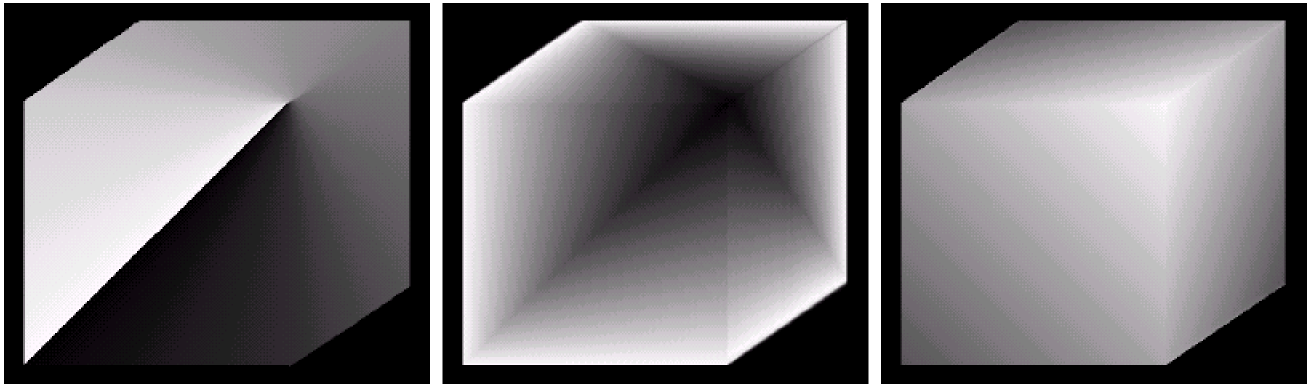
HSI (Hue Saturation Intensity)

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.

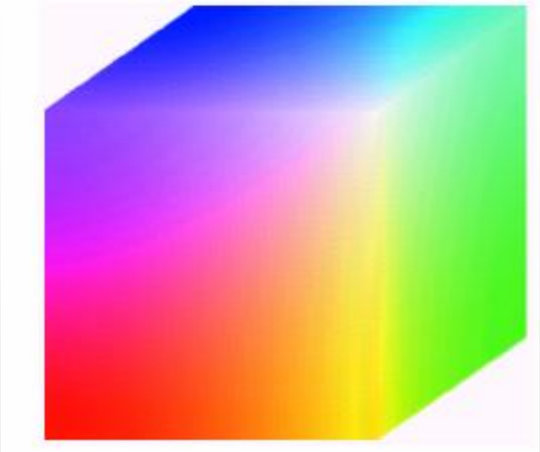


Componentes HSI

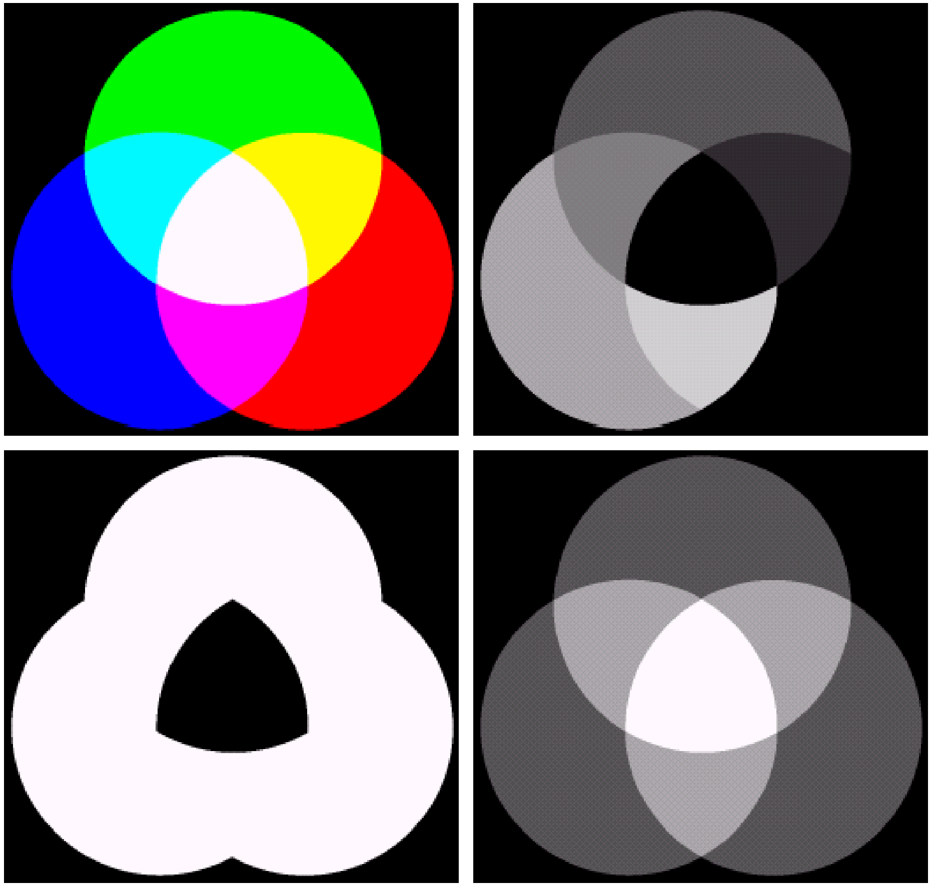


a b c

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



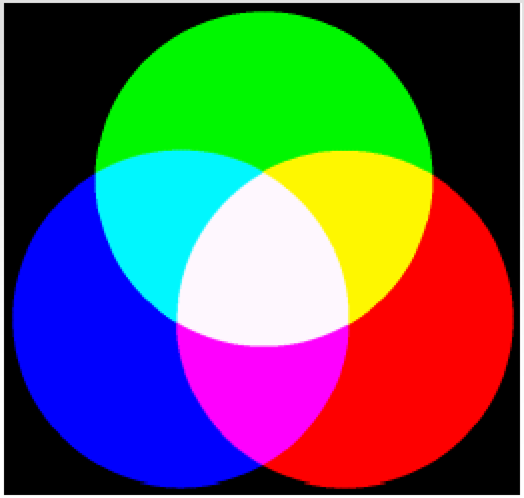
Componentes HSI



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.

Componentes HSI Modificados



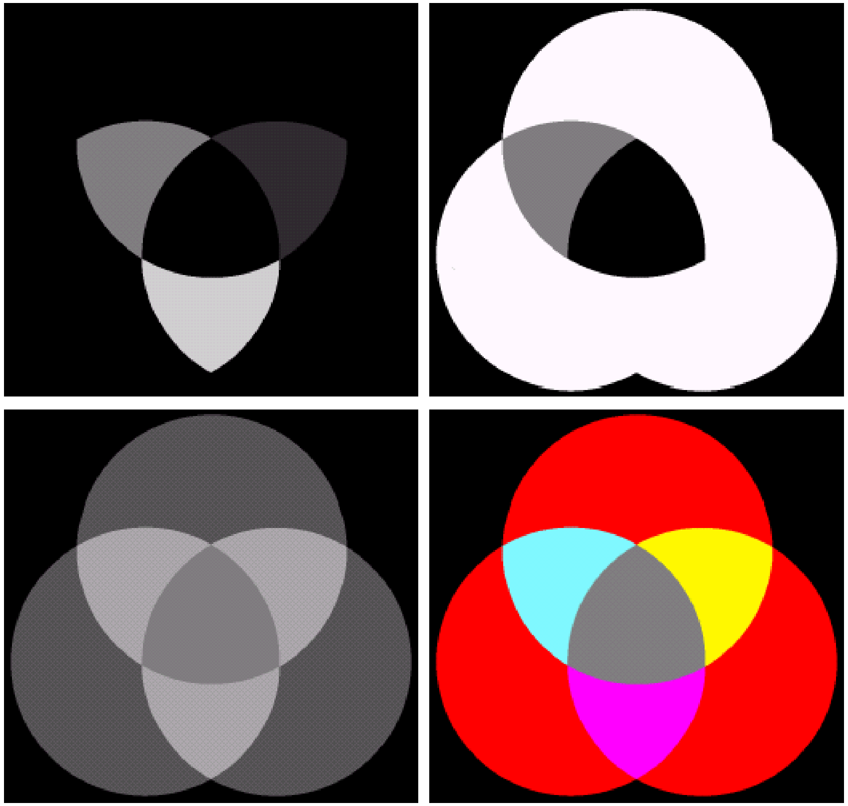


FIGURE 6.17 (a)–(c) Modified HSI component images. (d) Resulting RGB image. (See Fig. 6.16 for the original HSI images.)

Técnica do Fatiamento de Intensidade

Processamento de imagens em Pseudo-Cores

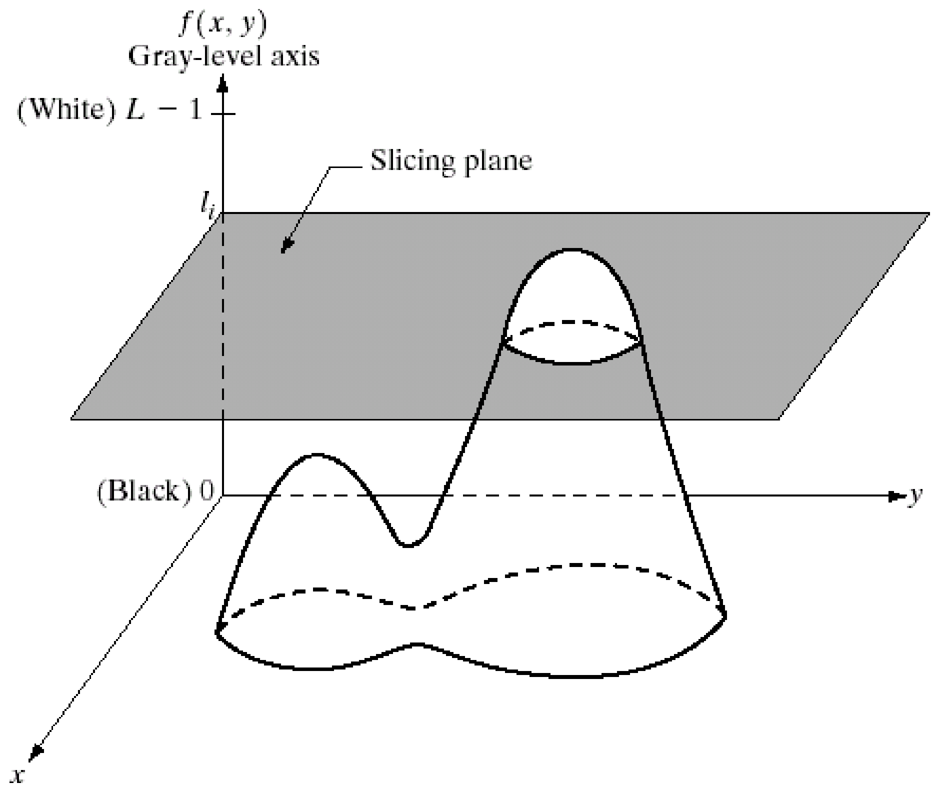


FIGURE 6.18 Geometric interpretation of the intensity-slicing technique.

Fatiamento por intensidade (dois níveis)

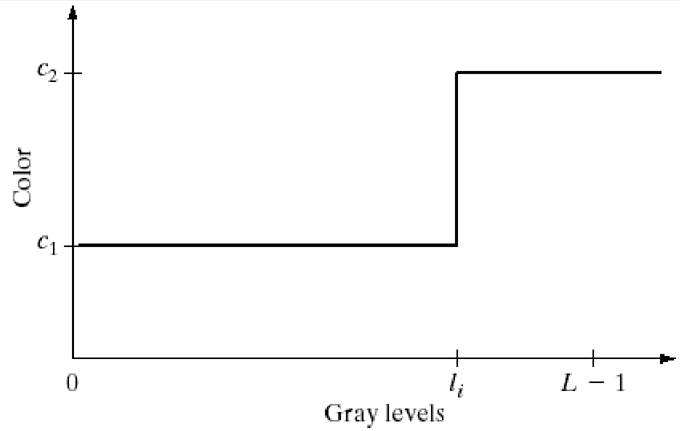
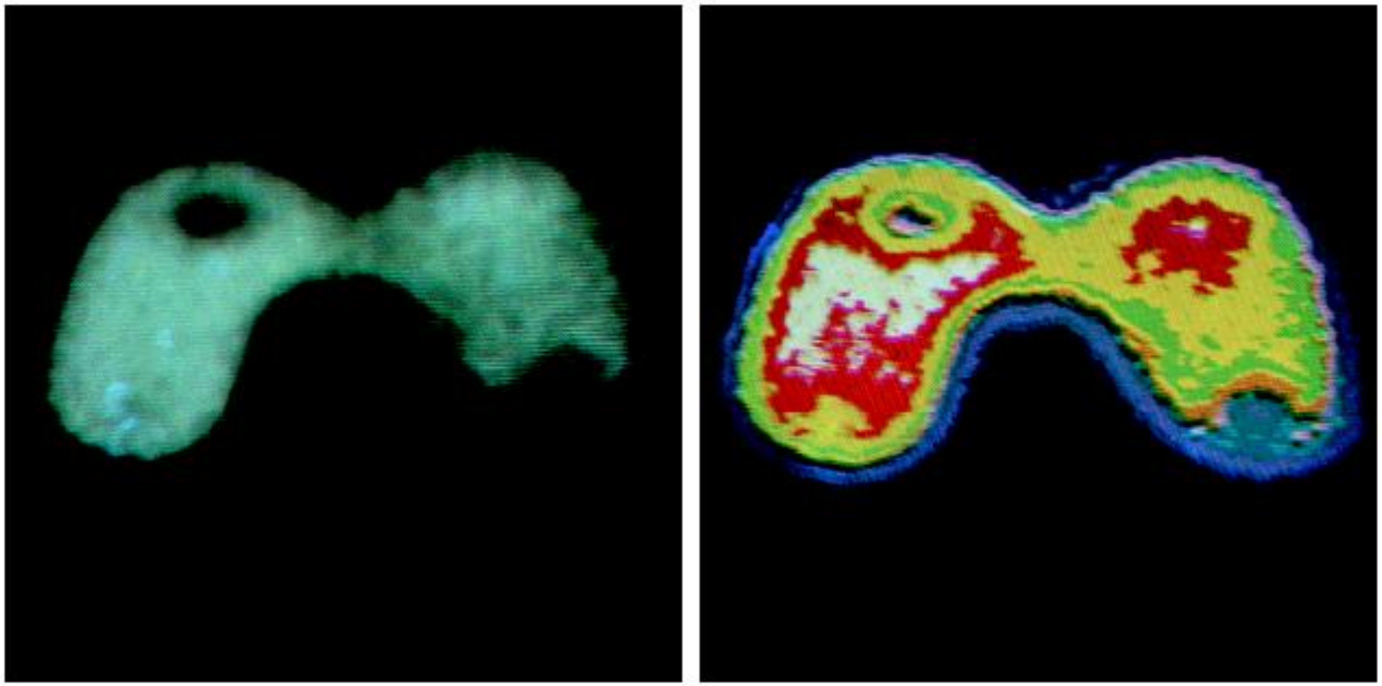


FIGURE 6.19 An alternative representation of the intensity-slicing technique.

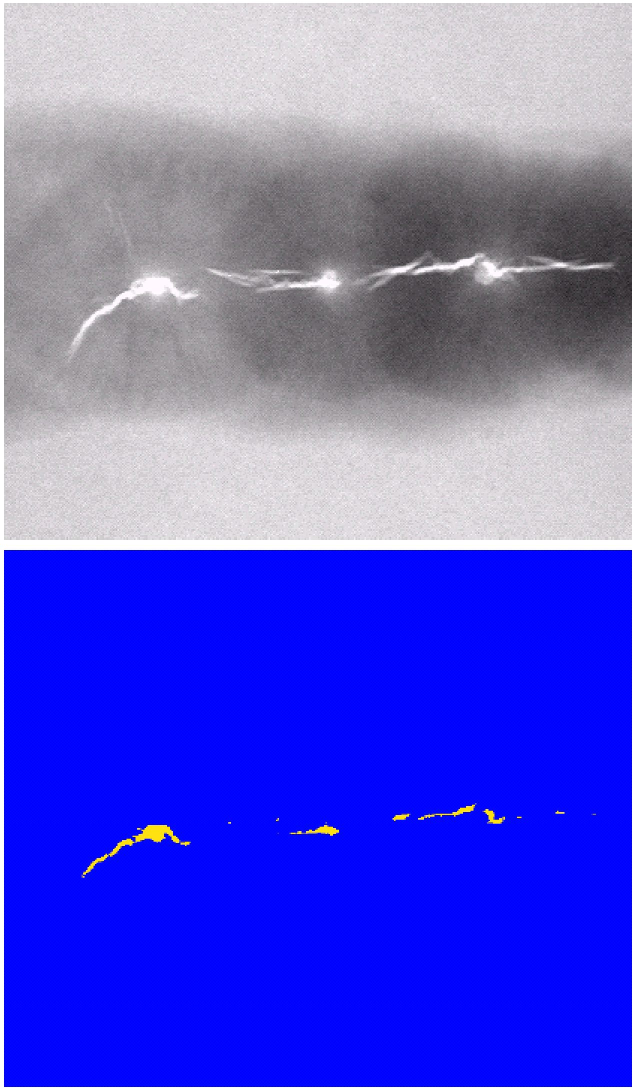
Aplicação do Fatiamento de Densidade



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.)

Codificação de Cores



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.)

Melhor visibilidade da falha

Cores associadas à intensidade de chuvas

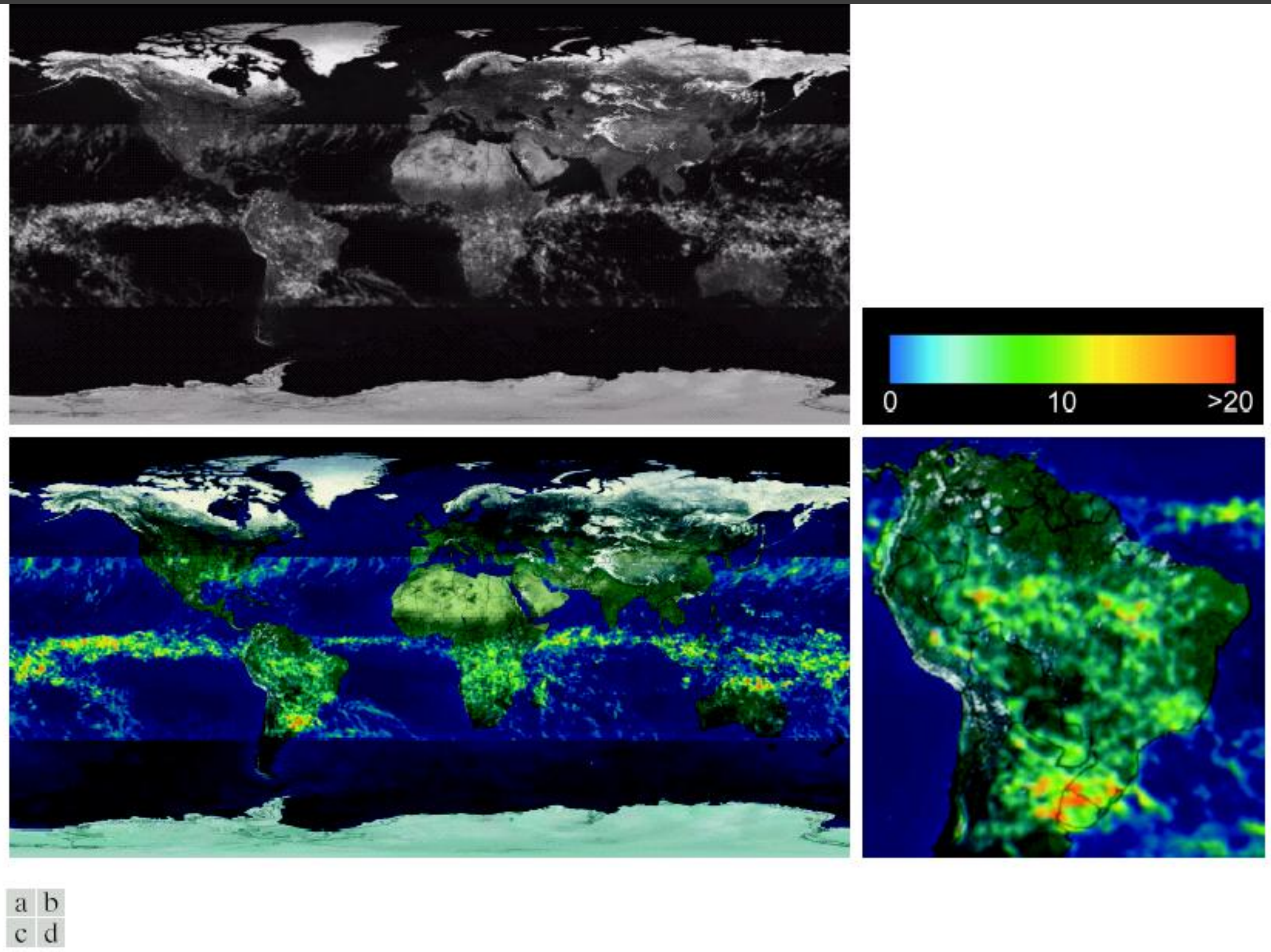


FIGURE 6.22 (a) Gray-scale image in which intensity (in the lighter horizontal band shown) corresponds to average monthly rainfall. (b) Colors assigned to intensity values. (c) Color-coded image. (d) Zoom of the South America region. (Courtesy of NASA.)

Processamento de Pseudo Cores

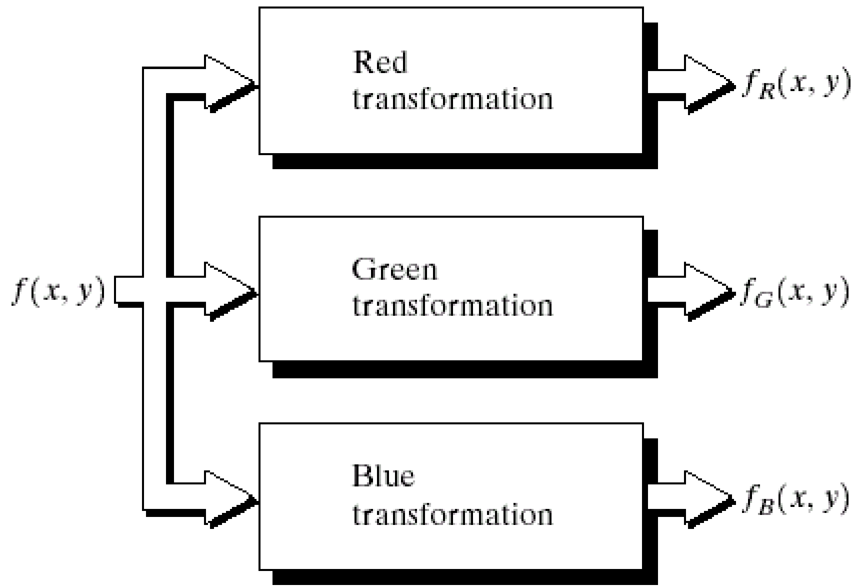
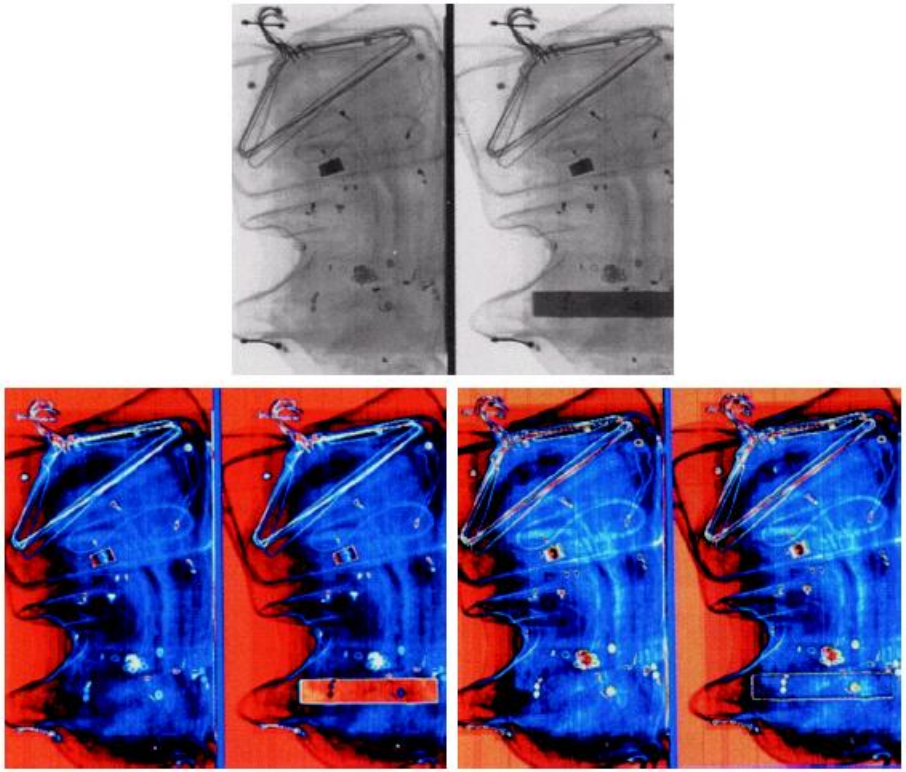


FIGURE 6.23 Functional block diagram for pseudocolor image processing. f_R, f_G, and f_B are fed into the corresponding red, green, and blue inputs of an RGB color monitor.

Melhora da visualização pelo uso de Pseudo Cores



a
b c

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

Transformações Utilizadas

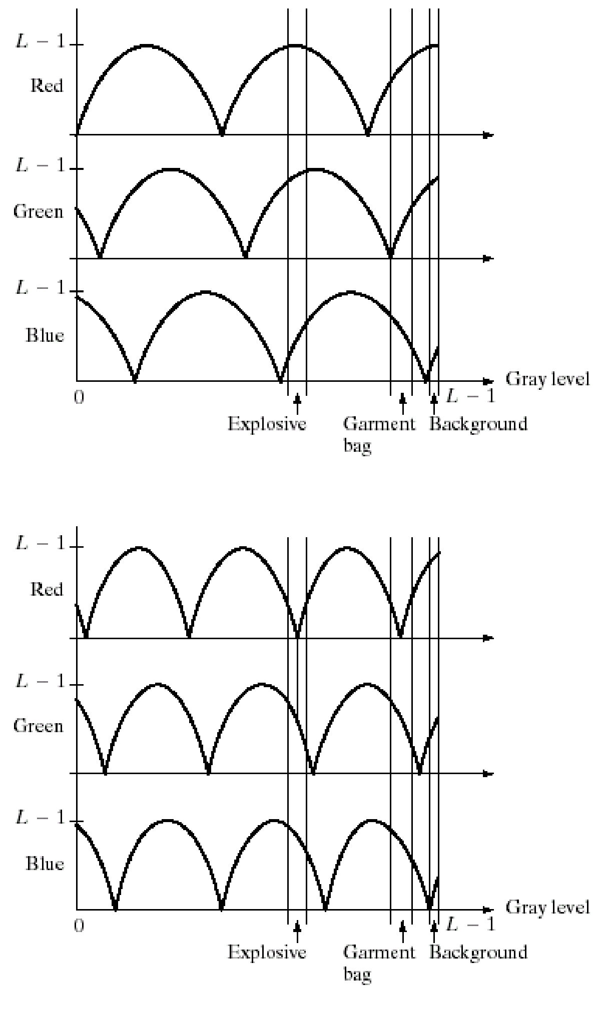


FIGURE 6.25 Transformation functions used to obtain the images in Fig. 6.24.

Codificação de Pseudo cores com diversas imagens monocromáticas

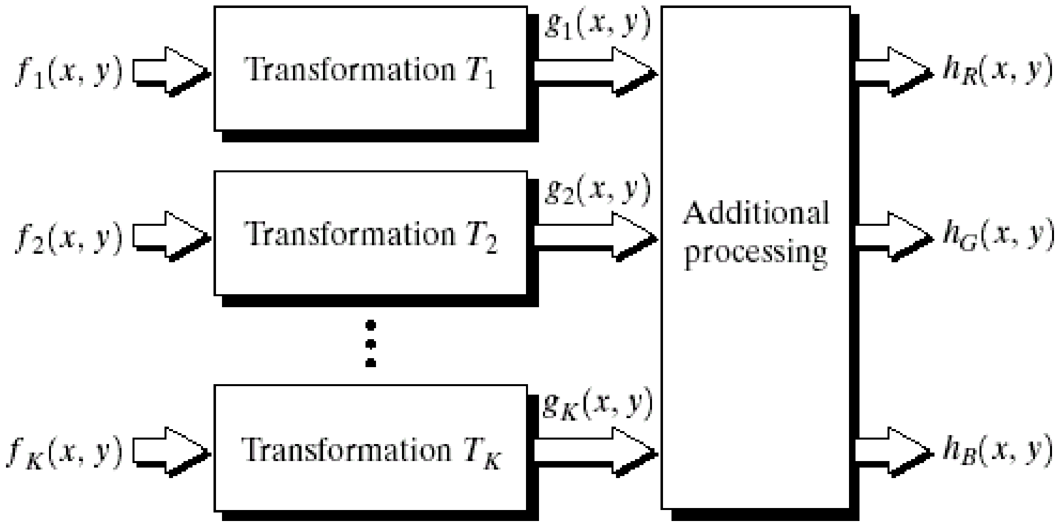
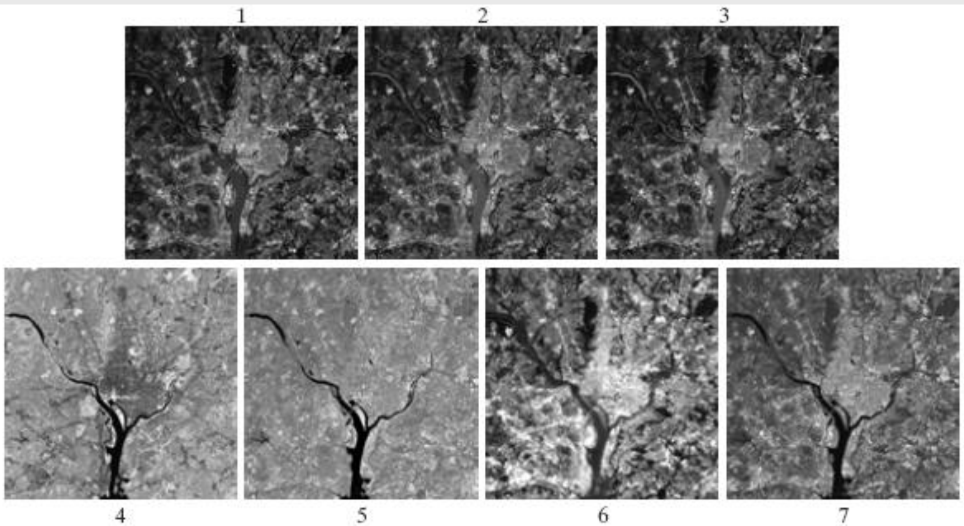
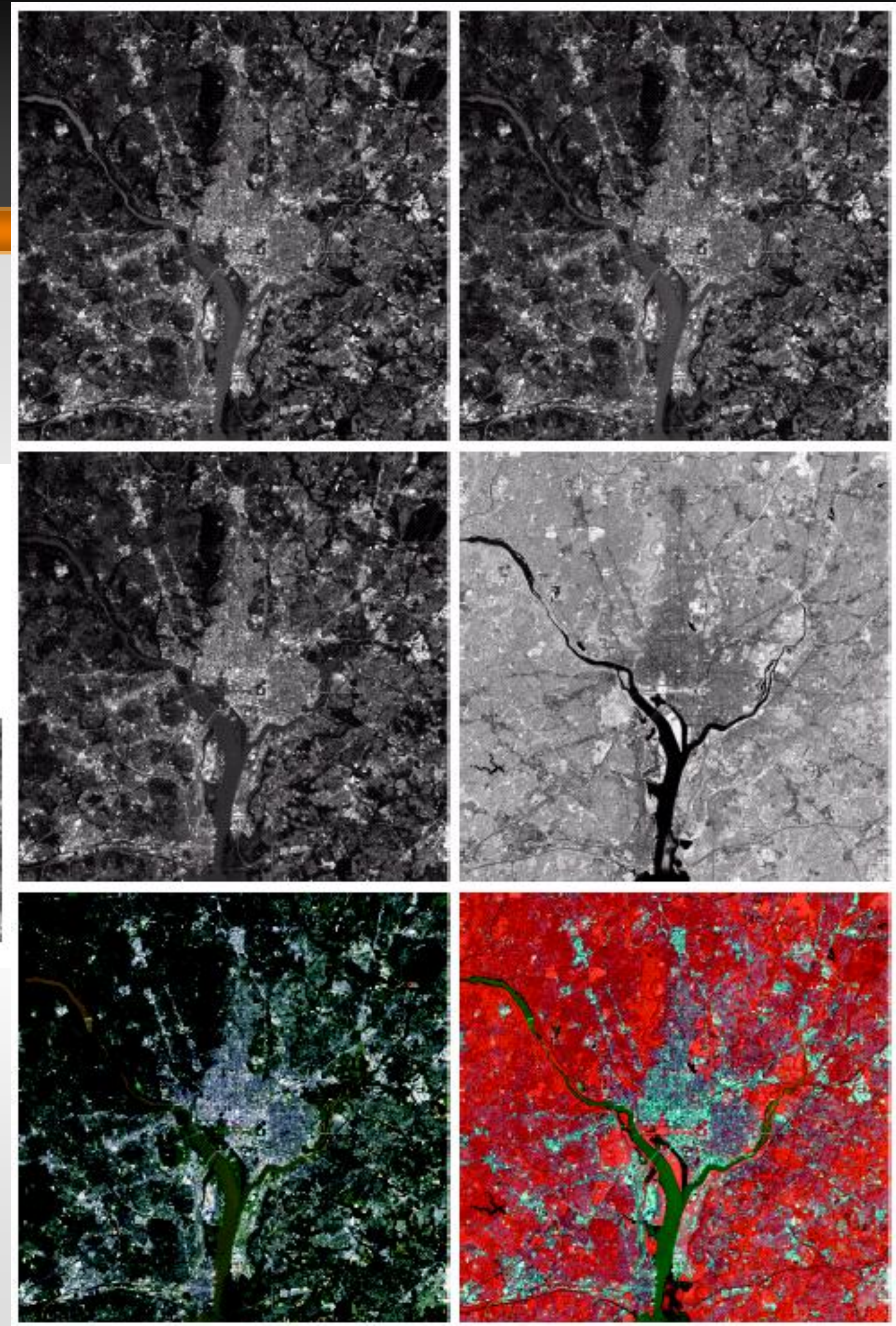


FIGURE 6.26 A pseudocolor coding approach used when several monochrome images are available.

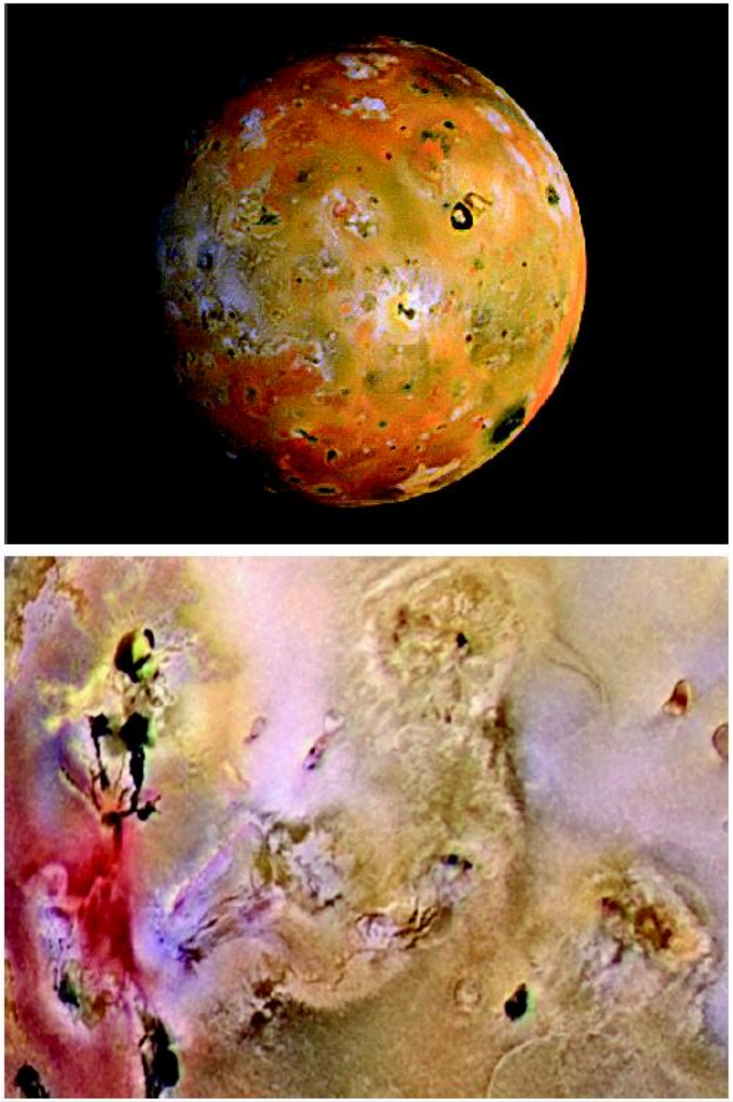
a b
c d
e f

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.)





Jupiter *pseudo colorido*



a
b

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

Máscaras Espaciais para imagens coloridas em tons de cinza

a b

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

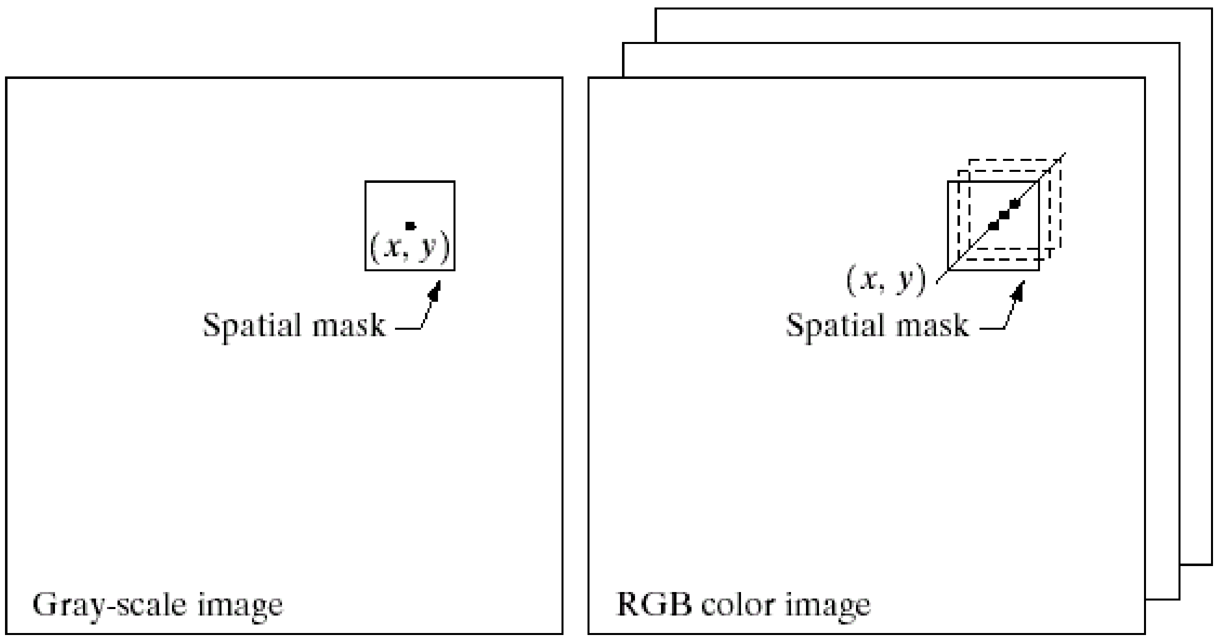


Imagem colorida e seus componentes

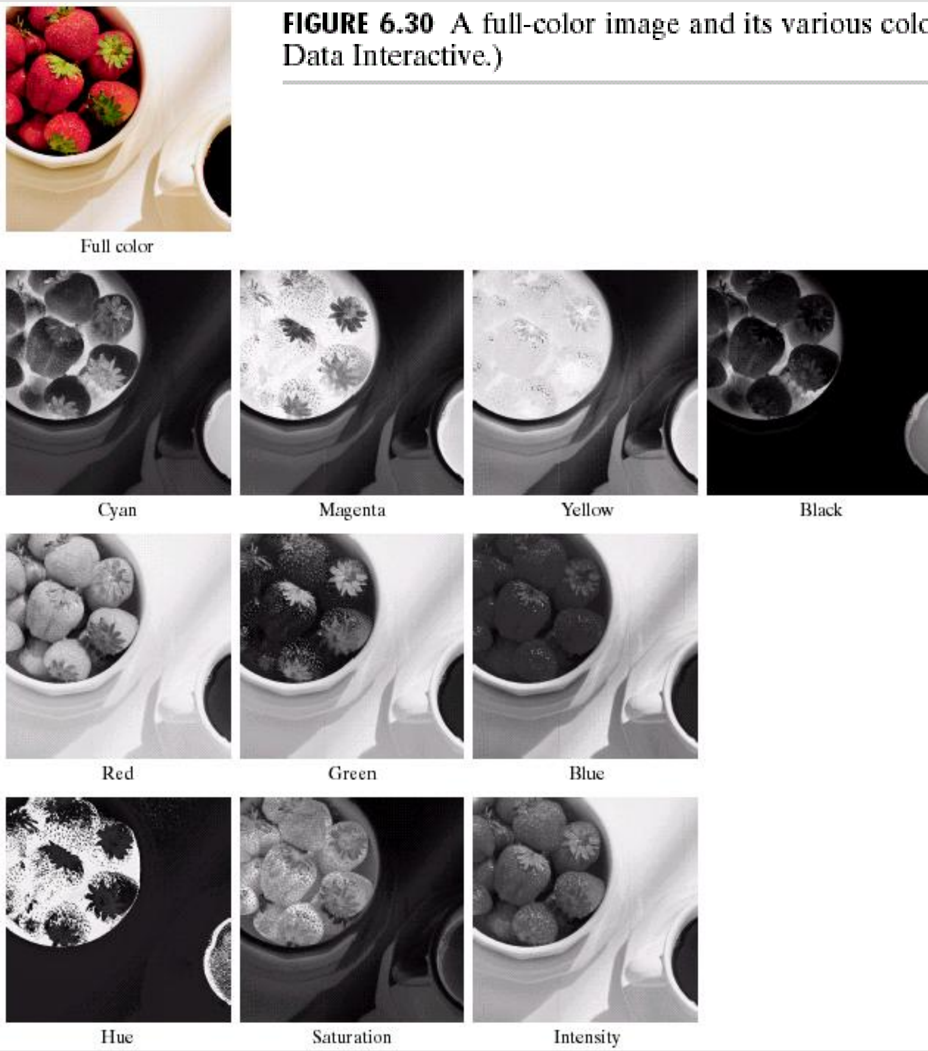
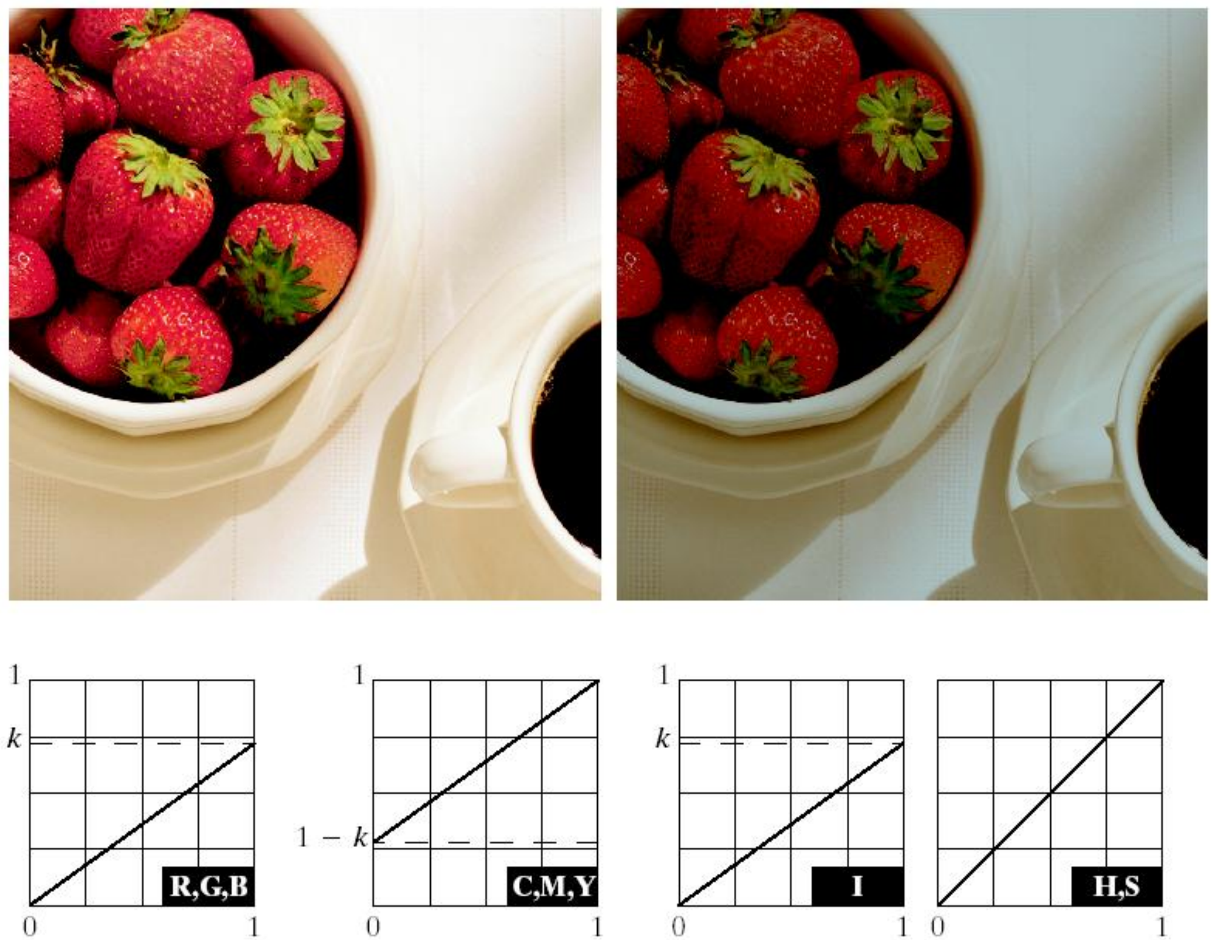


FIGURE 6.30 A full-color image and its various color-space components. (Original image courtesy of Med-Data Interactive.)

Ajuste de Intensidade



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.)

Cores Complementares

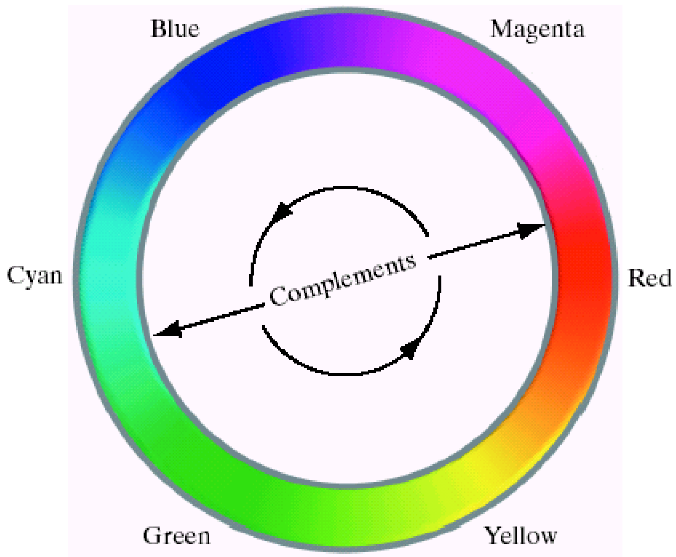
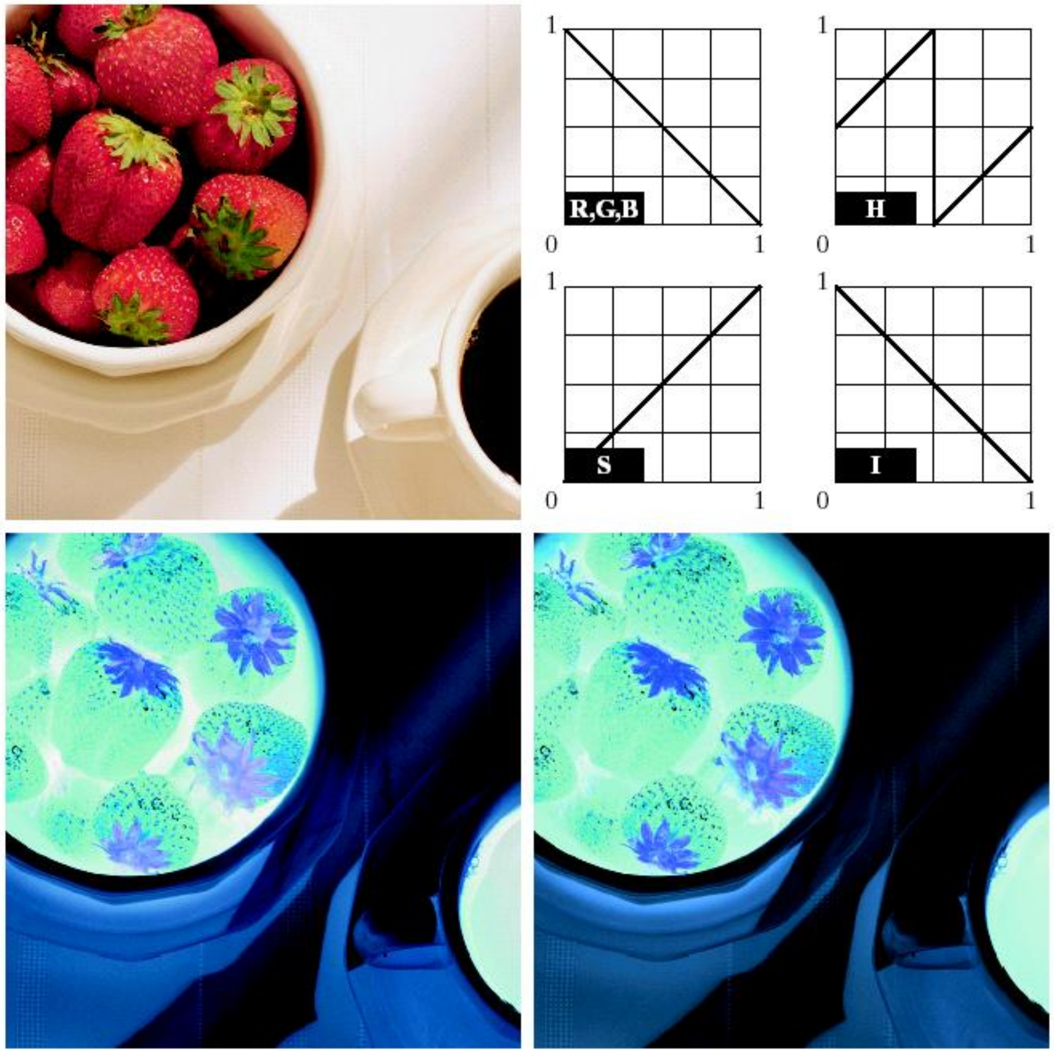


FIGURE 6.32 Complements on the color circle.

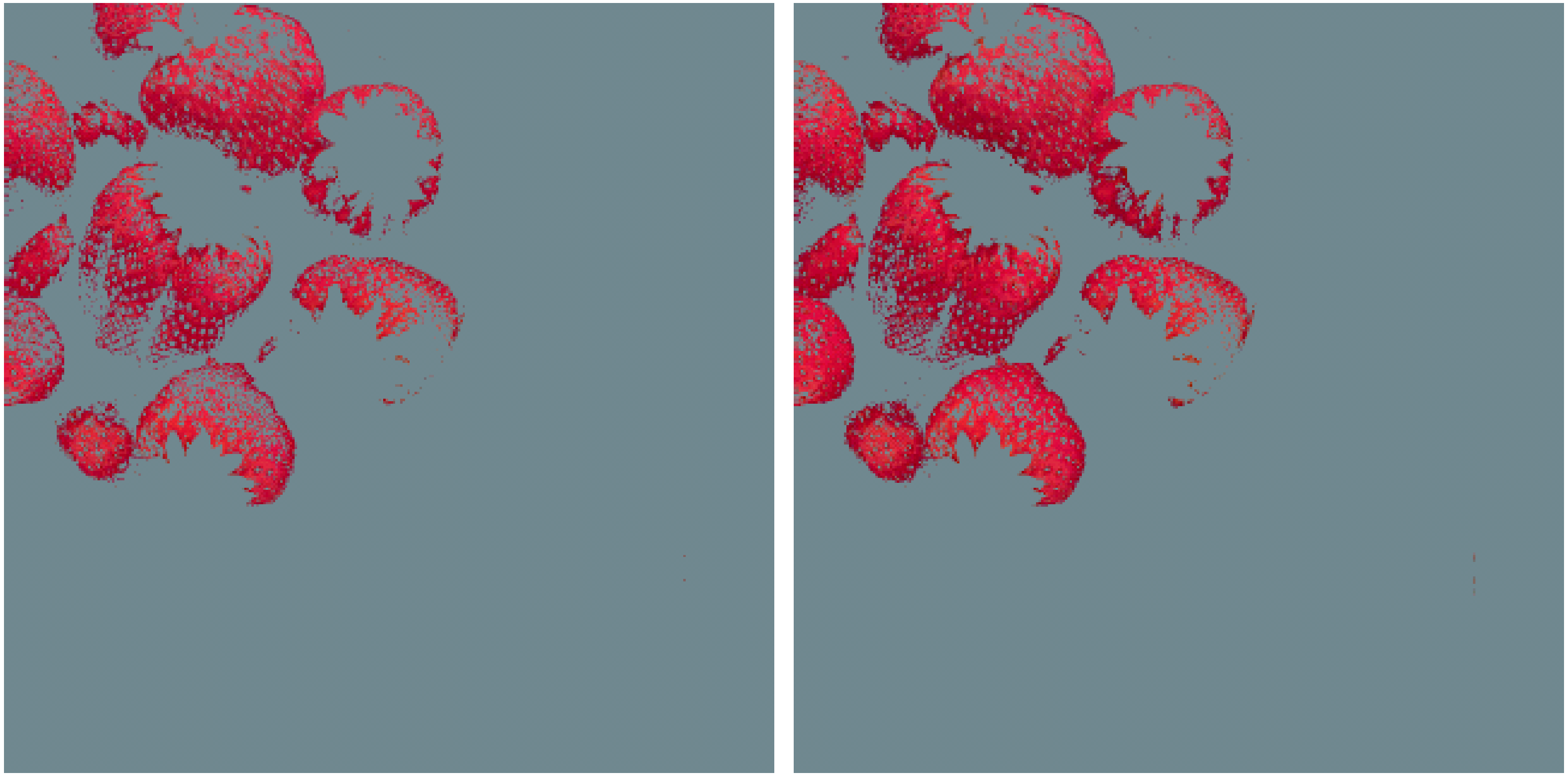
Transformações de Complemento de Cores



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.

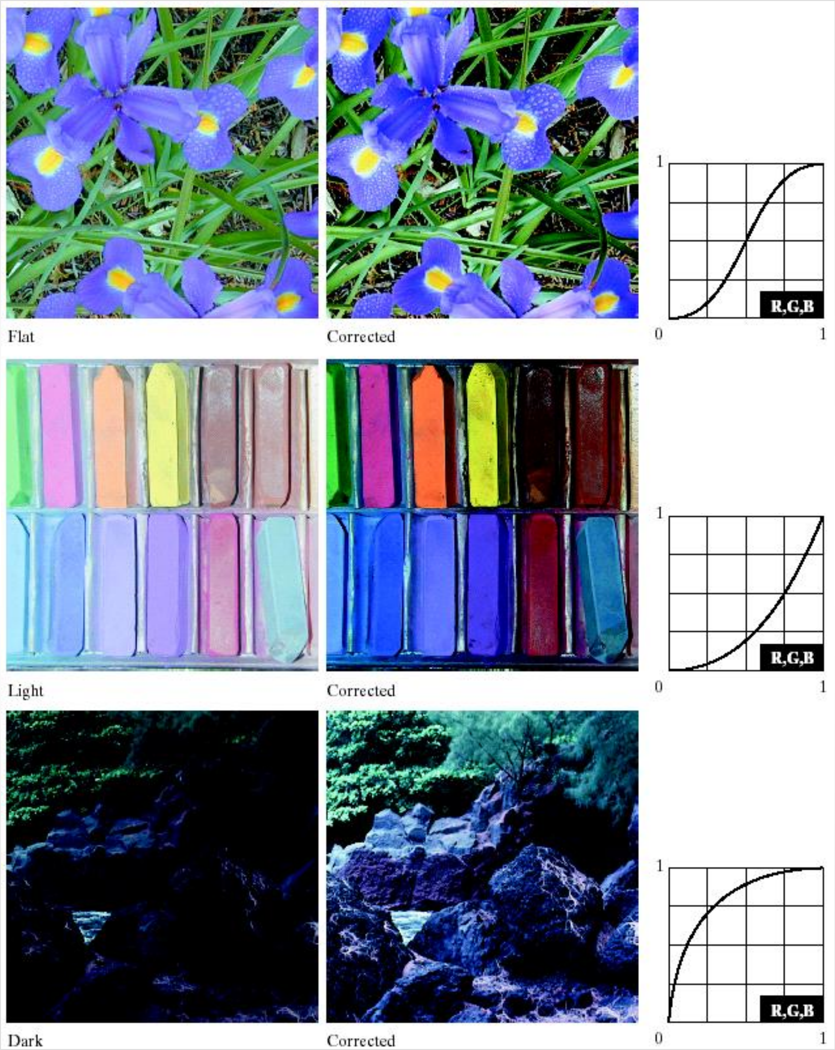
Transformações de fatiamento de cores



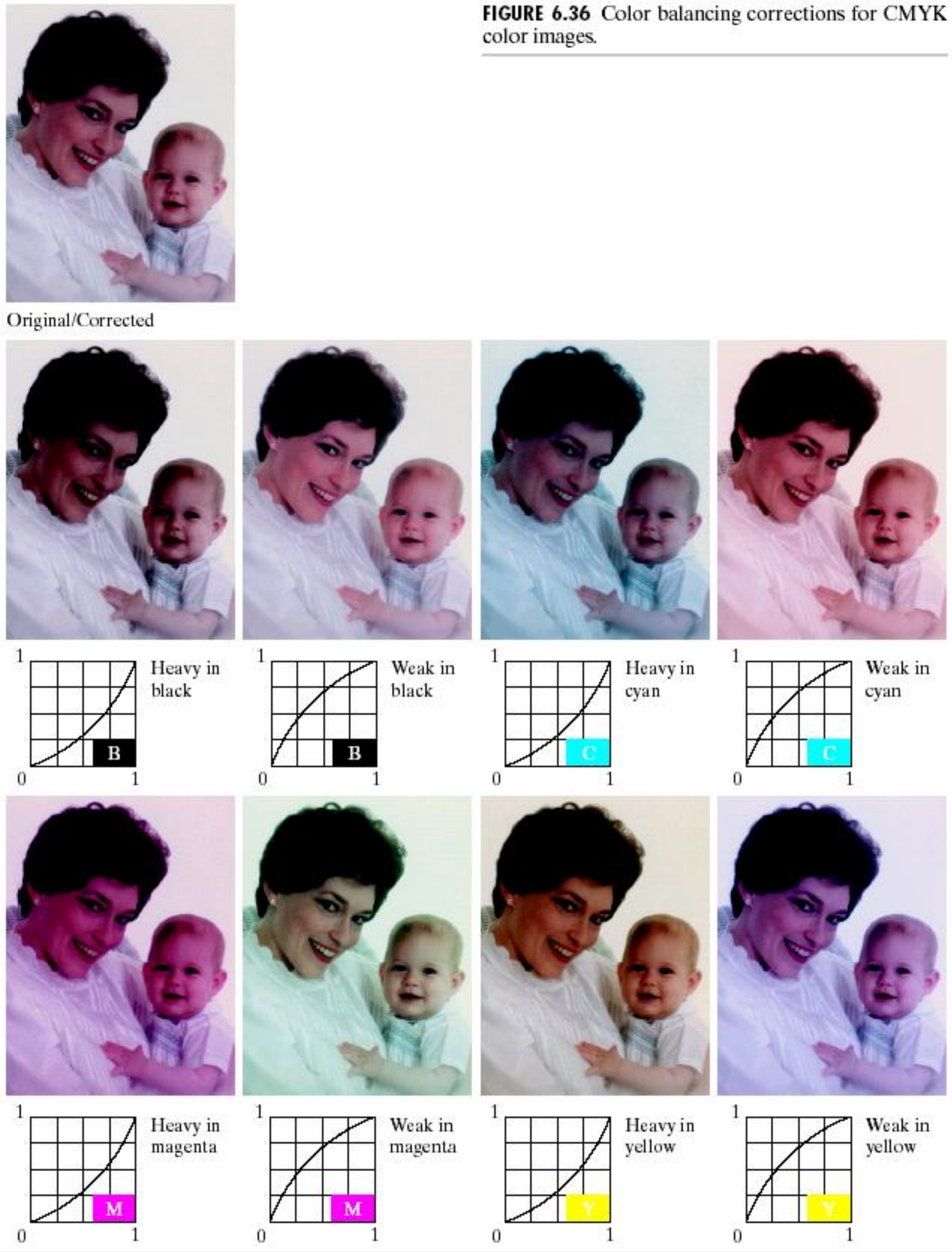
a b

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).

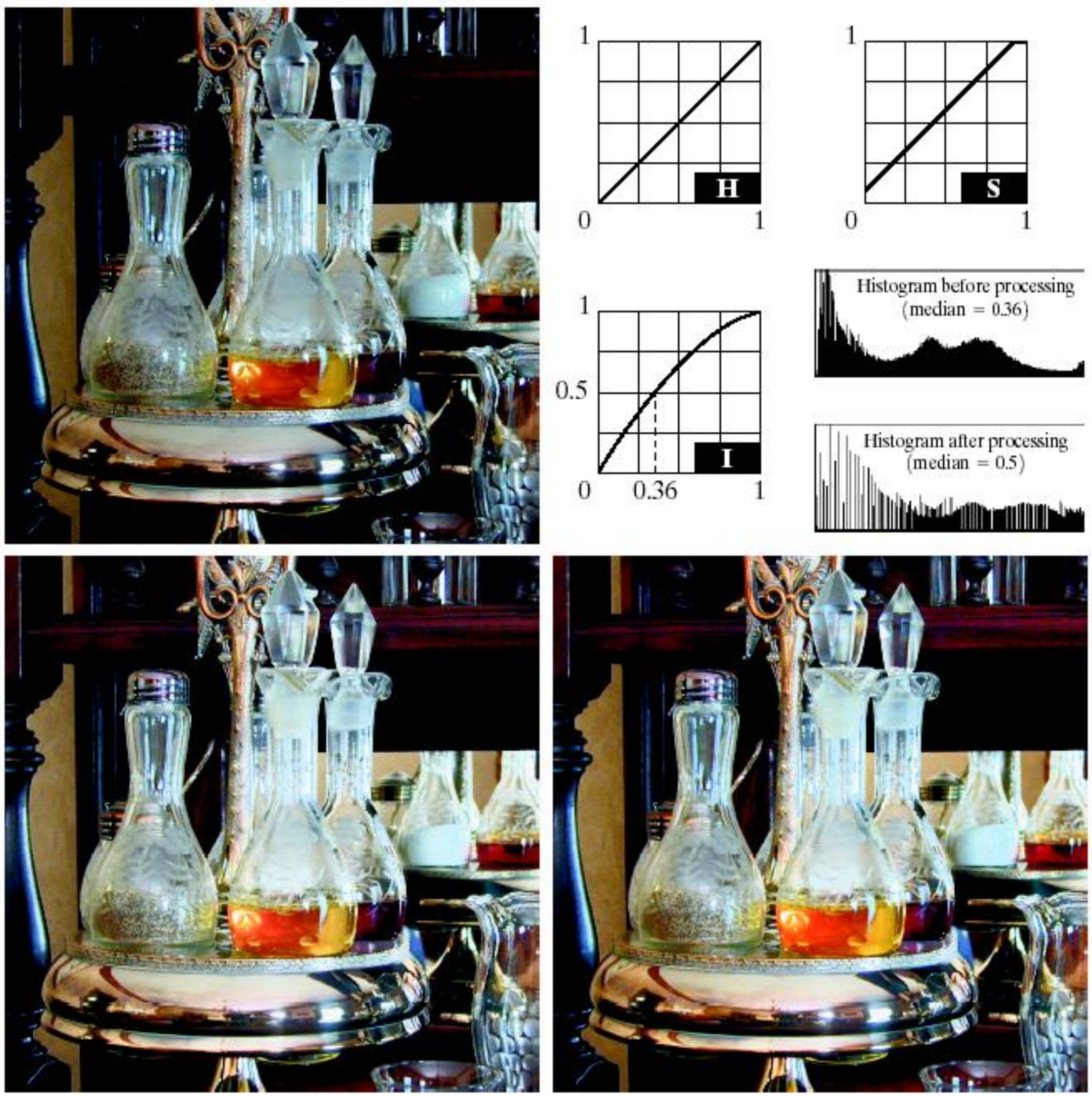
FIGURE 6.35 Tonal corrections for flat, light (high key), and dark (low key) color images. Adjusting the red, green, and blue components equally does not alter the image hues.



Correção de Balanceamento de cores para CMYK



Equalização de histograma + ajuste de saturação



a b
c d

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

Decomposição em Componentes RGB

a b
c d

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

Decomposição HSI

a b c

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

“Amaciamento de Imagem”

a b c

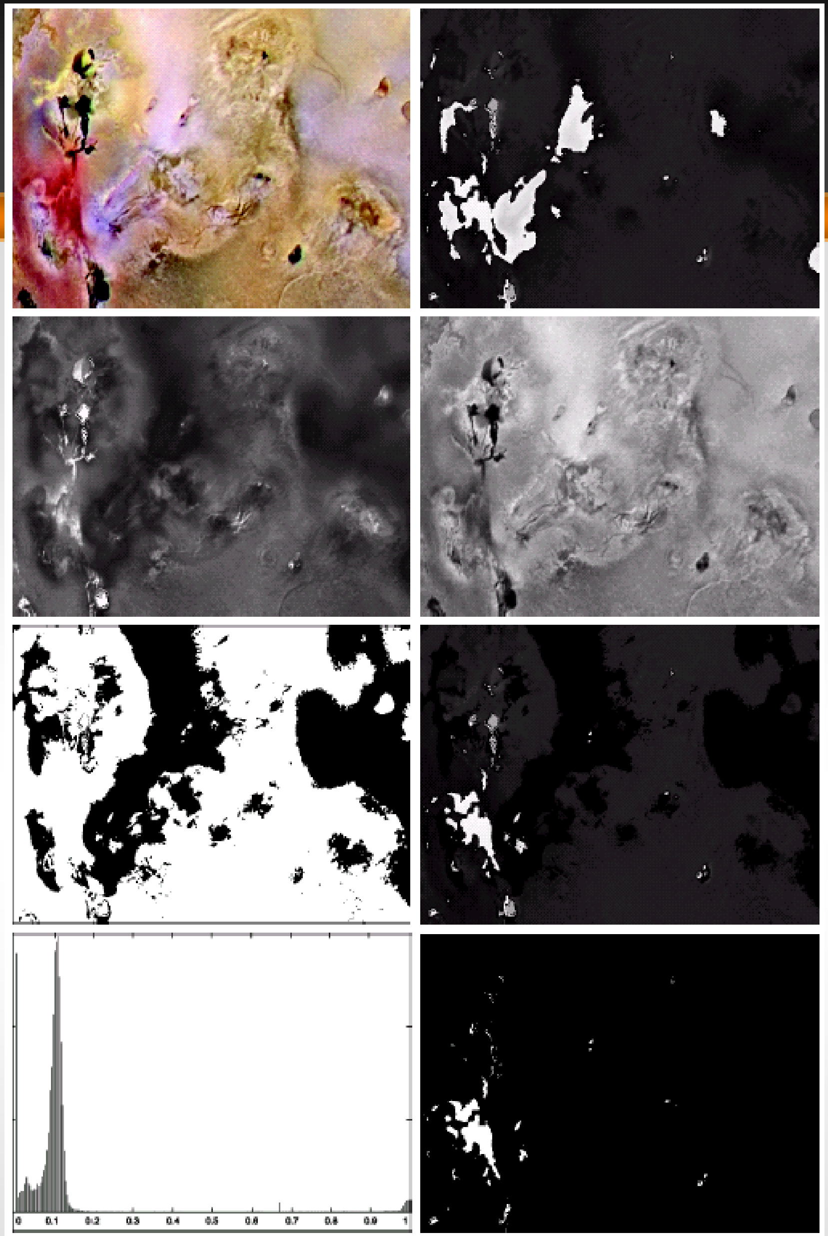
FIGURE 6.40 Image smoothing with a 5 × 5 averaging mask. (a) Result of processing each RGB component image. (b) Result of processing the intensity component of the HSI image and converting to RGB. (c) Difference between the two results.

“Aguçamento” de imagem

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.

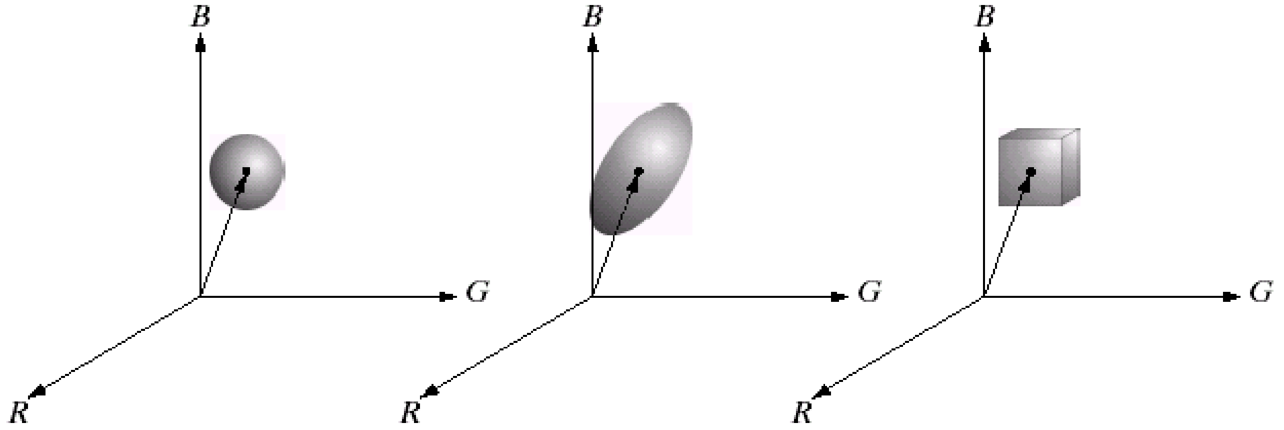
Segmentação de Imagem



a b
c d
e f
g h

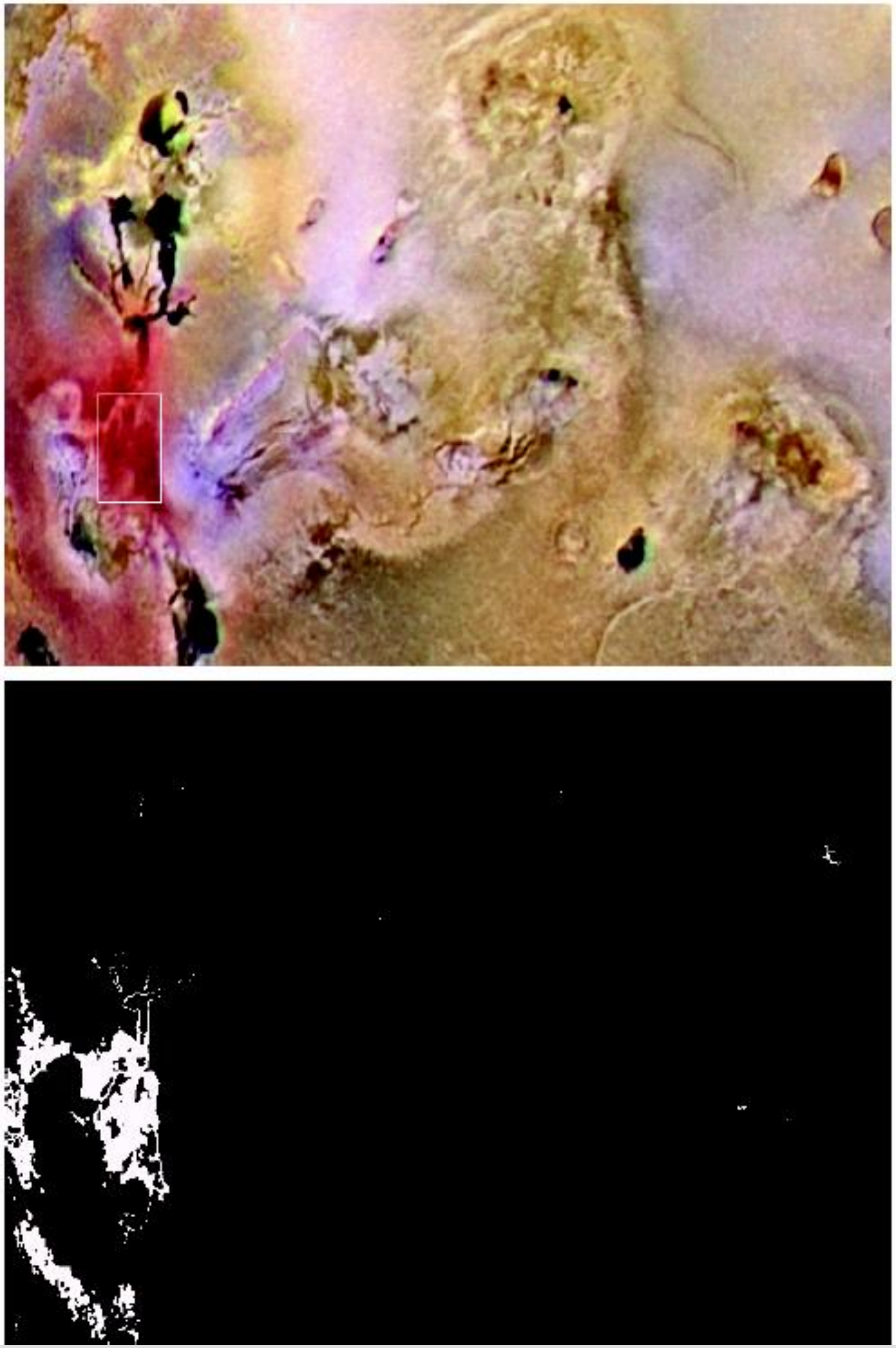
FIGURE 6.42 Image segmentation in HSI space. (a) Original. (b) Hue. (c) Saturation. (d) Intensity. (e) Binary saturation mask (black = 0). (f) Product of (b) and (e). (g) Histogram of (f). (h) Segmentation of red components in (a).

Segmentação Vetorial RGB



a b c

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



a
b

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).

Segmentação no espaço RGB

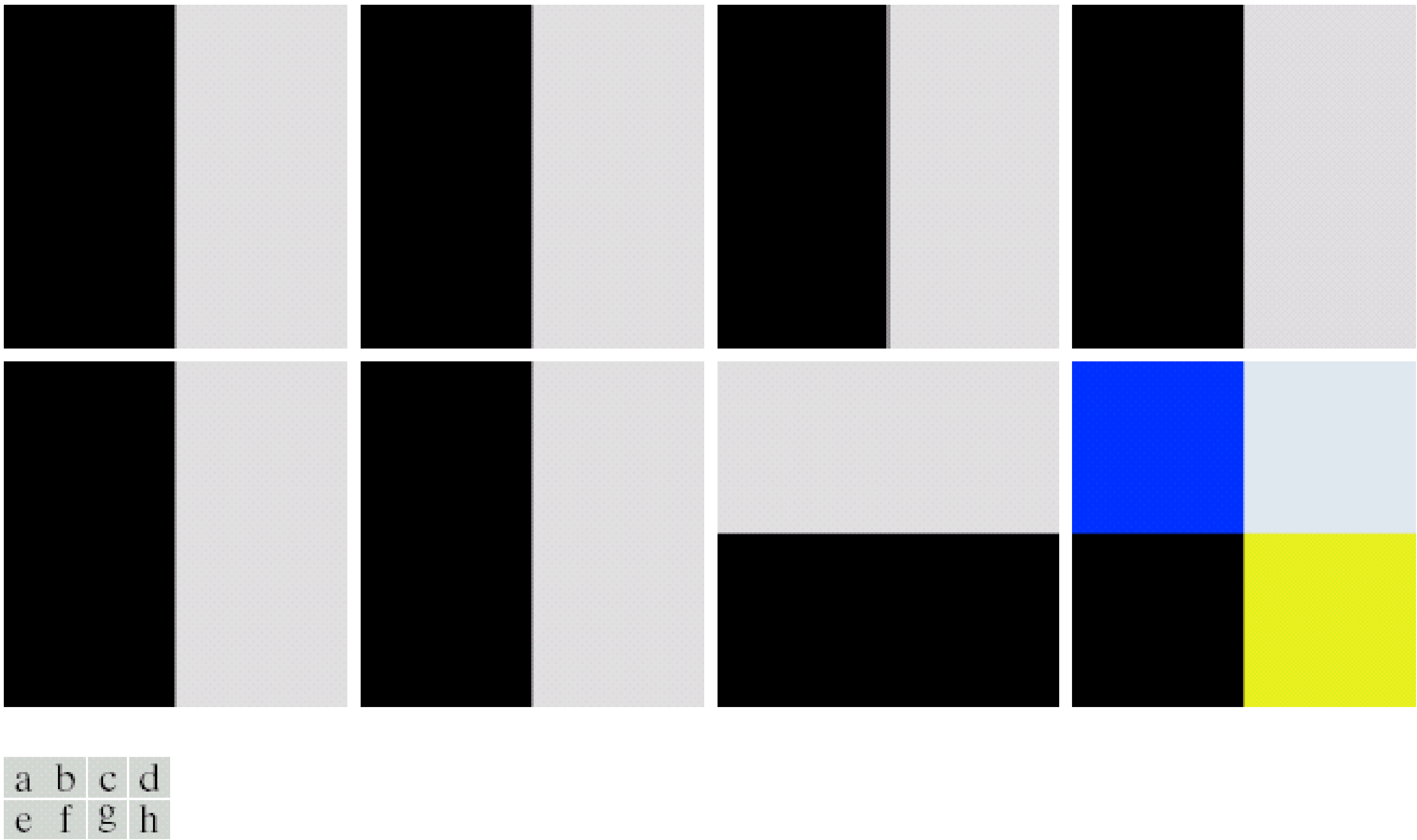


FIGURE 6.45 (a)–(c) R, G, and B component images and (d) resulting RGB color image. (f)–(g) R, G, and B component images and (h) resulting RGB color image.

Gradientes

a b
c d

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).

Gradientes

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).

Imagem Corrompida por Ruído Gaussiano

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).]

Componentes HSI da imagem com ruídos

a b c

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

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.

a	b
c	d

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