# CMY color model

- Each color is represented by the three secondary colors --- cyan ($C$), magenta ($M$), and yellow ($Y$).
- It is mainly used in devices such as color printers that deposit color pigments.
- It is related to the RGB color model by the following:

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

+

=

+

# YIQ color model

- Each color is represented in terms of a **luminance** component ($Y$) and two **chrominance** or color components: **inphase** ($I$) and **quadrature** ($Q$) components.

- Used in United States commercial TV broadcasting (NTSC system).

- The $Y$ component provides all the video information required by a monochrome TV receiver/monitor.

- It is related to the RGB model by:

$$\begin{bmatrix} Y \\ I \\ Q \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ 0.596 & -0.275 & -0.321 \\ 0.212 & -0.523 & 0.311 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

- The main advantage of the YIQ model is that the luminance and chrominance components are decoupled and can be processed separately.

# HSI or HSV color model

- Each color is specified in terms of its **Hue** (*H*), **Saturation** (*S*) and **intensity** (*I*) or **value** (*V*).

- Note that the *I* in HSI model is different than the *I* in YIQ model. This model is sometimes referred to as HSV instead of HSI.

- The main advantages of this model is that:
  - Chrominance (*H*, *S*) and luminance (*I*) components are decoupled.
  - Hue and saturation is intimately related to the way the human visual system perceives color.

- In short, the RGB model is suited for image color generation, whereas the HSI model is suited for image color description.

- It is related to the RGB model as follows:

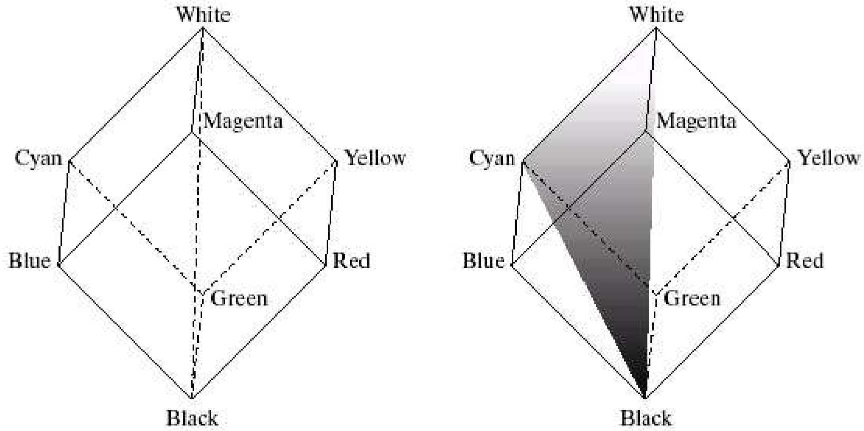
$$V = \frac{1}{3}(R + G + B)$$

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

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

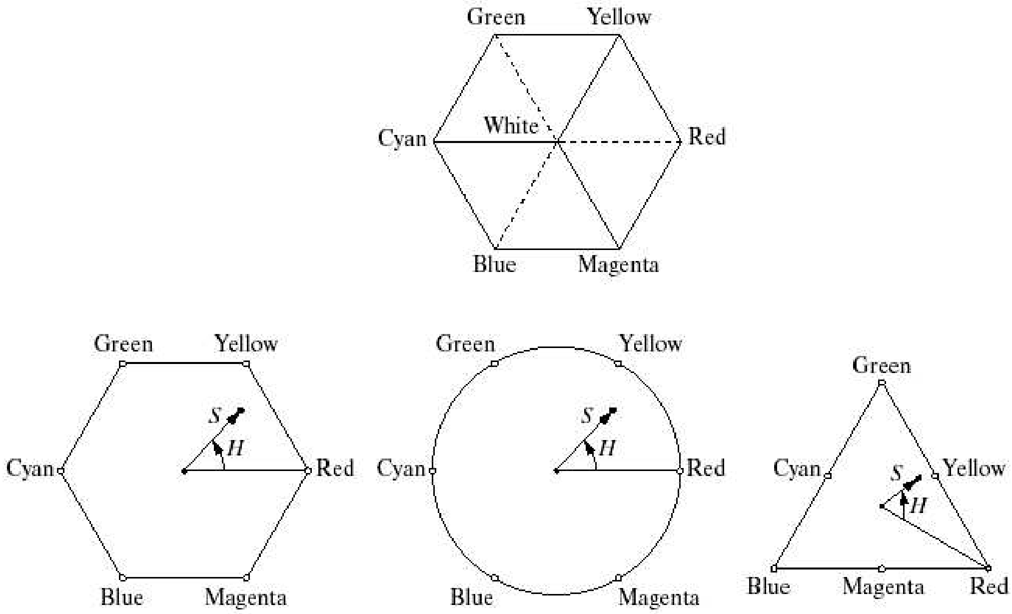
$$\theta = \cos^{-1}\left\{ \frac{\frac{1}{2}\left[(R - G) + (R - B)\right]}{\left[(R - G)^2 + (R - B)(G - B)\right]^{1/2}} \right\}$$

- Equations for inverse transformations are given in the text (pp. 299-300).



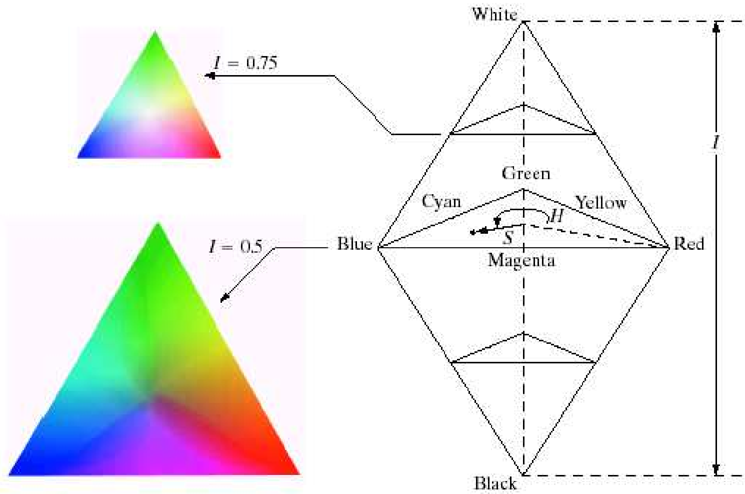

a b

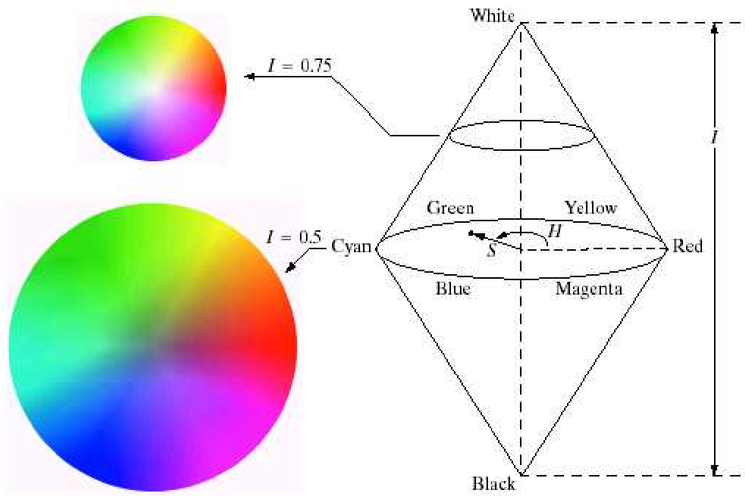
**FIGURE 6.12** Conceptual relationships between the RGB and HSI color models.

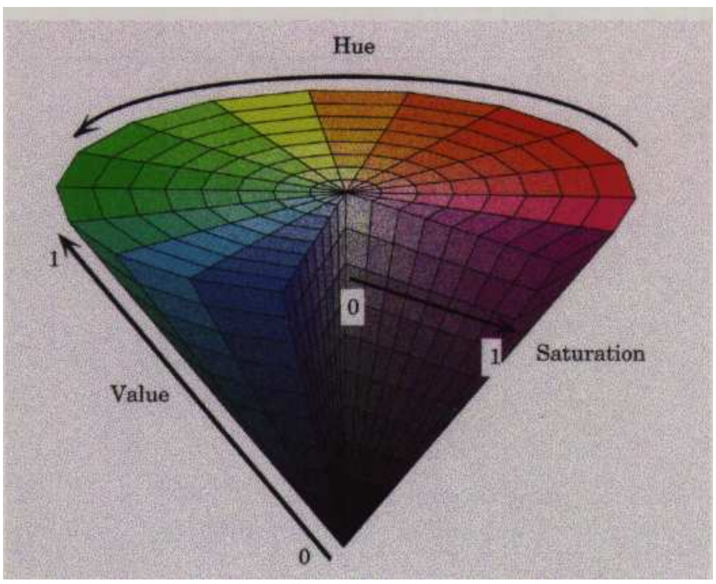



a
b c d

**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.

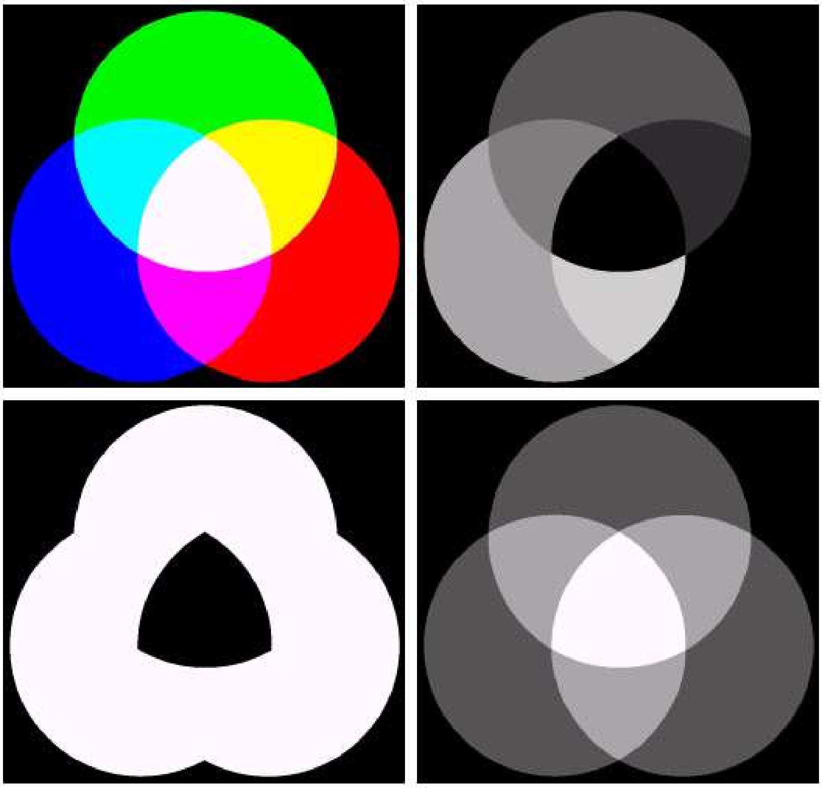

White
I = 0.75
I
Green
Cyan
Yellow
H
S
I = 0.5
Blue
Red
Magenta
Black


White
I = 0.75
I
Green
Yellow
I = 0.5
Cyan
H
S
Red
Blue
Magenta
Black


Hue
1
0
1
Saturation
Value
0

# Manipulation of HSI components

- Consider the primary colors chart below and the corresponding 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.

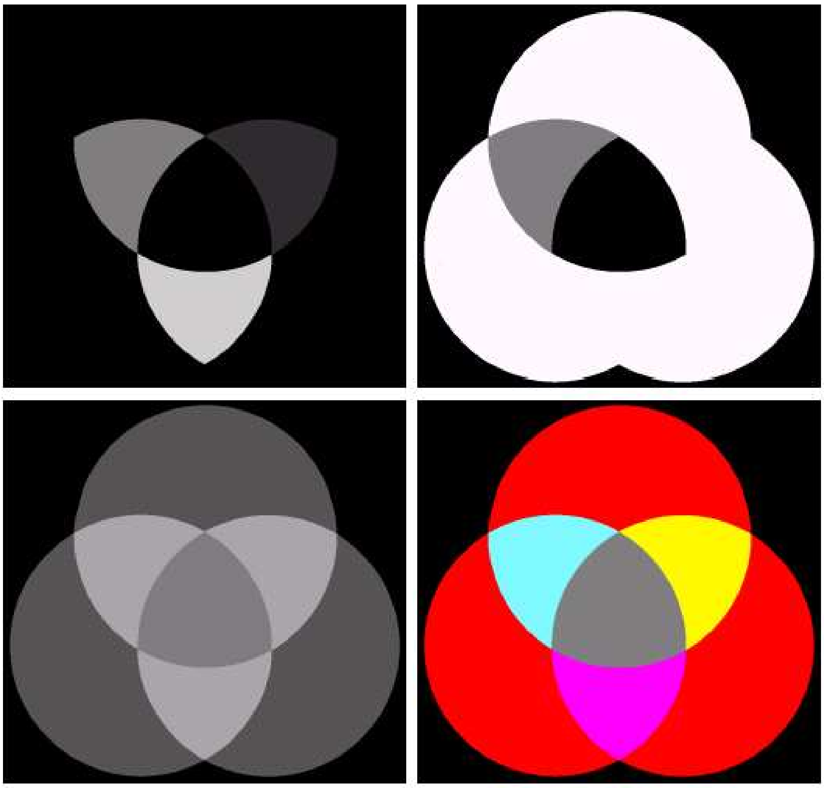
- To change the individual color of any region in the RGB image, we change the value of the corresponding region in the Hue image. Then we convert the new H image with the original S and I images to get the transformed RGB image.

- We can modify saturation and intensity like-wise, by manipulating the corresponding component image in the HSI model.

- For example, we can manipulate the RGB color chart as follows:

    - Change all the green and blue regions into red by setting to 0 the corresponding regions in the H component image.
    - Reduce the saturation of the Cyan region by ½ by manipulating the corresponding region in the S component image.
    - Reduce by ½ the intensity of the white region by manipulating the corresponding region in the I component image.

- The resulting H, S, and I images are converted back to RGB and displayed below.



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.)

# Pseudo Coloring

- Assign colors to monochrome images, based on various properties of their graylevel content.

- It is mainly used for human visualization and interpretation.

- Several transformations can be used for this purpose.

- For example, we may use a different enhancement technique to highlight different features and color code them appropriately.

# Intensity Slicing

- View an image as a 2-D intensity function. Slice the intensity (or density) function by a plane parallel to the coordinate axes.

- Pixel with grayvalues above the plane are color coded with one color and those below are coded with a different color.

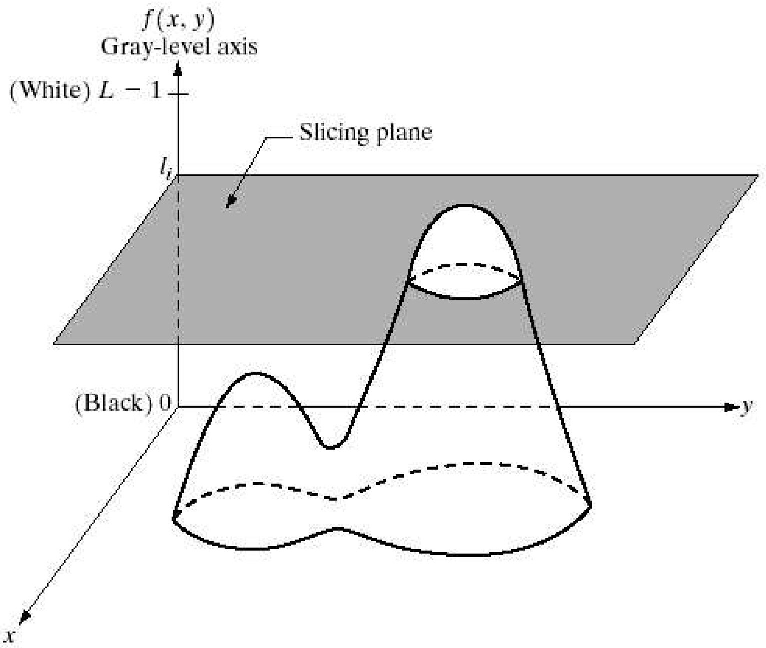
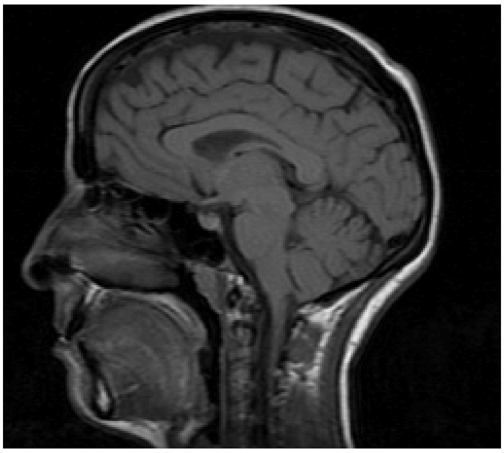



**FIGURE 6.18** Geometric interpretation of the intensity-slicing technique.

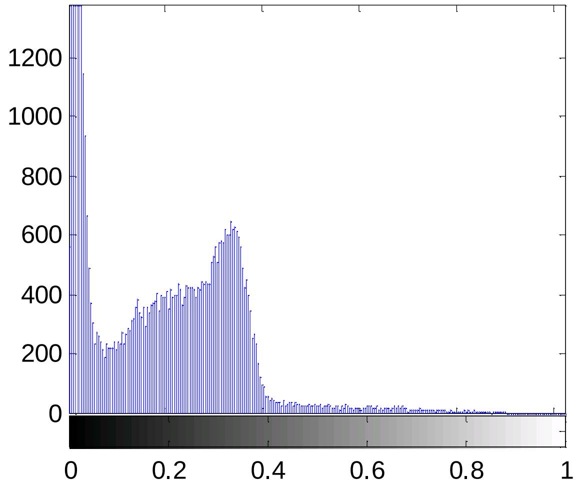
- This gives a two-color image. Similar to thresholding but with colors.

- Technique can be easily extended to more than one plane.

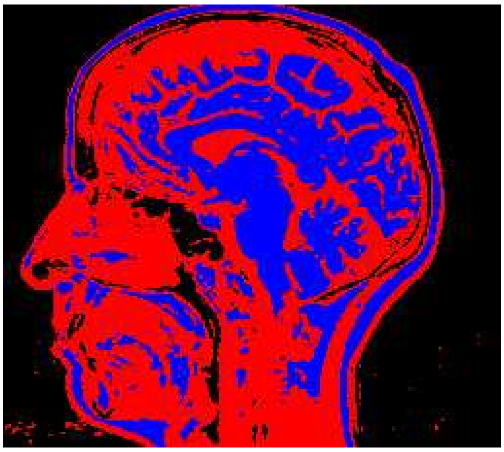
# Example



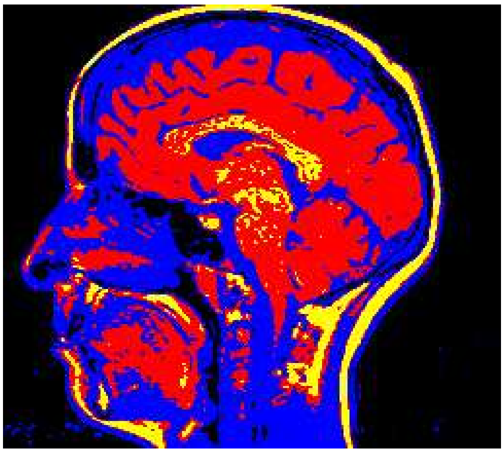
Monochrome Image




Histogram

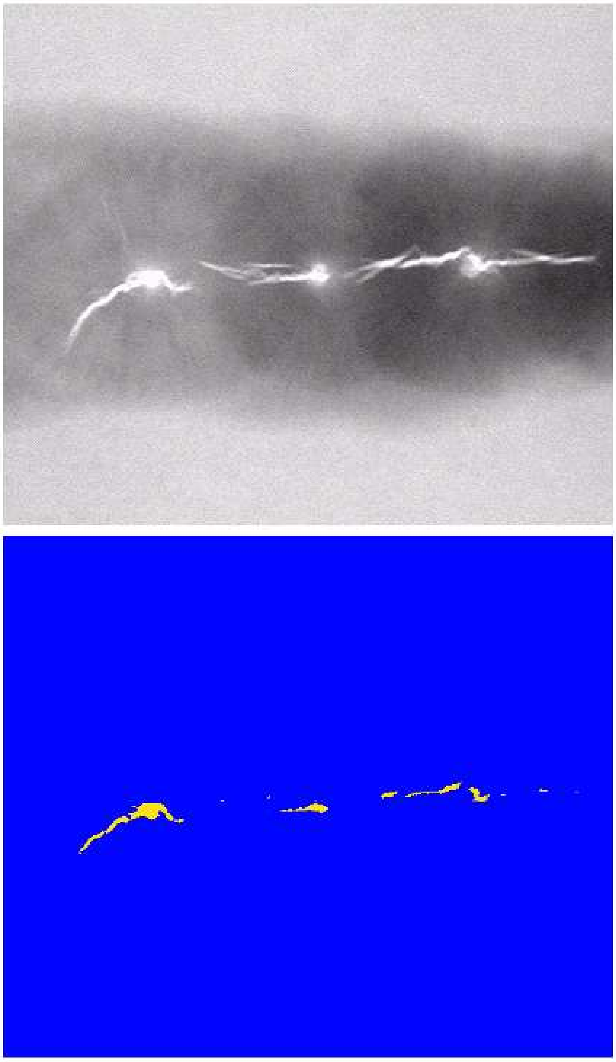


Intensity Slicing:
Two colors



Intensity Slicing:
Three colors

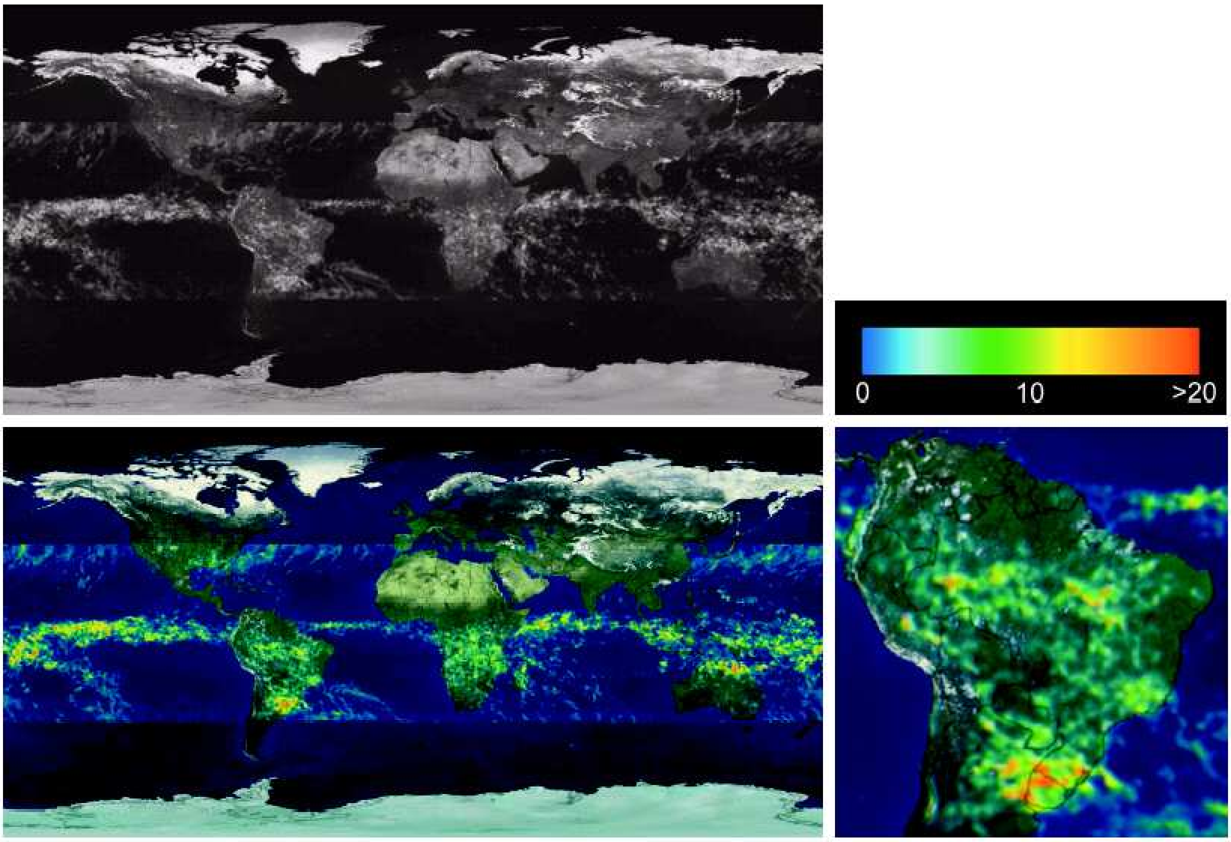
# Example



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.)

# Example




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.)

# Gray Level to Color Transformations

- Perform three independent transformations on the graylevel of an input monochrome image.
- The outputs of the three transformations are fed to the Red, Green, and Blue channels of a color monitor.

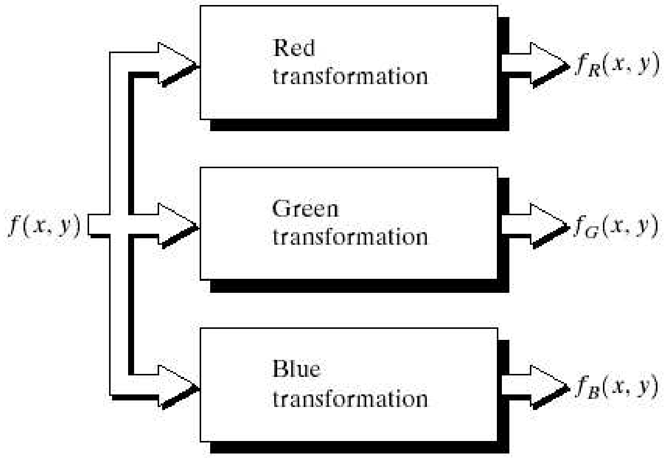



**FIGURE 6.23** Functional block diagram for pseudocolor image processing. $f_R$, $f_G$, and $f_B$ are fed into the corresponding red, green, and blue inputs of an RGB color monitor.

- Read example in page 309-310 of text.
- This technique can also be used to combine several monochrome images into a single composite color image.

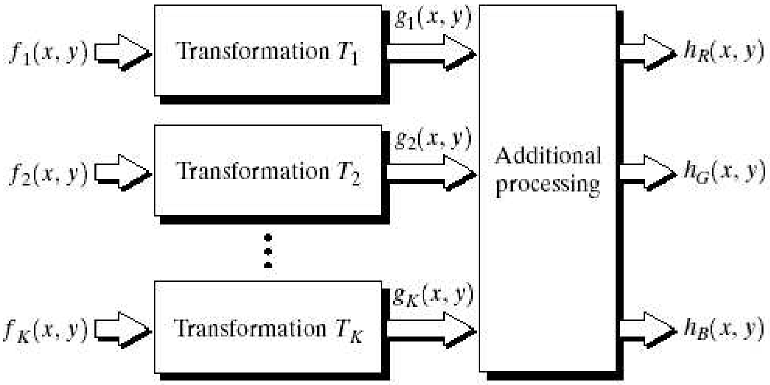
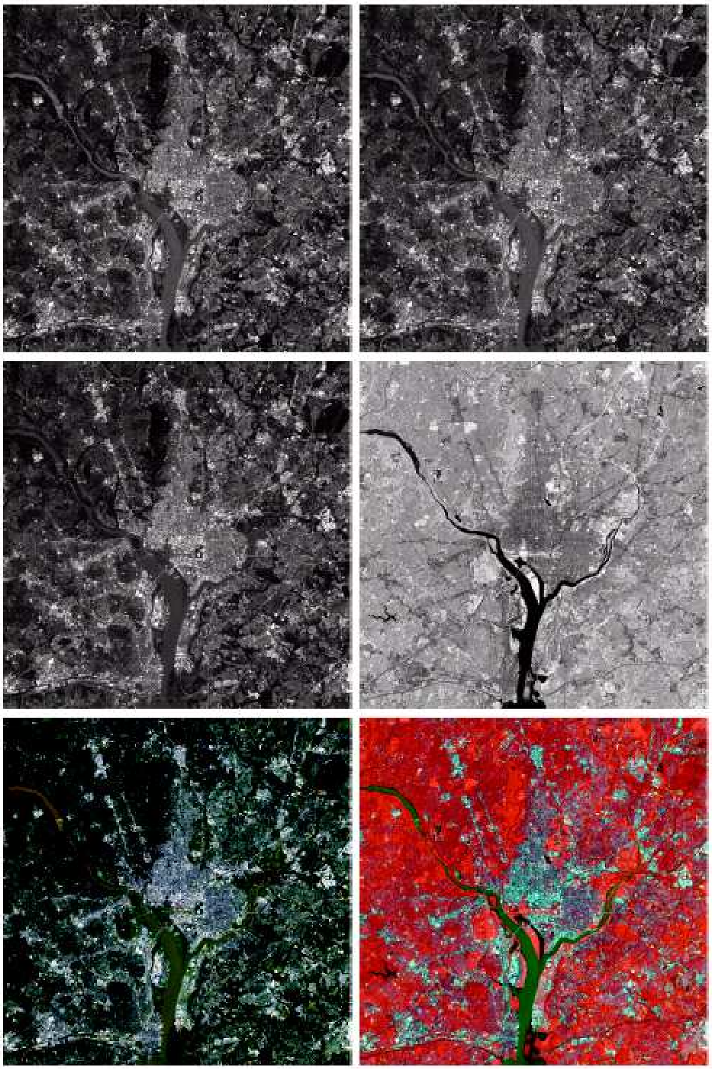



**FIGURE 6.26** A pseudocolor coding approach used when several monochrome images are available.

- This is frequently used in multispectral imaging, where different sensors produce individual monochrome images, each in a different spectral band.

# Example



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.)