4.2 Color Models in Images

- Color models and spaces used for stored, displayed, and printed images.

- **RGB Color Model for Displays**

  1. We expect to be able to use 8 bits per color channel for color that is accurate enough.

  2. However, in fact we have to use about 12 bits per channel to avoid an aliasing effect in dark image areas — contour bands that result from gamma correction.

  3. For images produced from computer graphics, we store integers proportional to intensity in the frame buffer. So should have a gamma correction between the frame buffer and the display.

  4. If gamma correction is applied to floats before quantizing to integers, before storage in the frame buffer, then in fact we can use only 8 bits per channel and still avoid contouring artifacts.

Subtractive color: CMY color Model

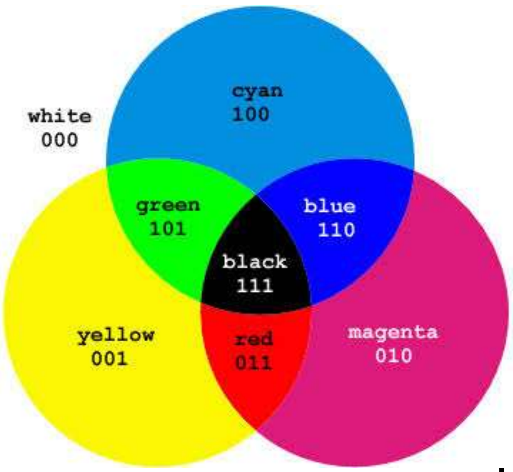
(Cyan, Magenta, Yellow)

- So far, we have effectively been dealing only with **additive color**. Namely, when two light beams impinge on a target, their colors add; when two phosphors on a CRT screen are turned on, their colors add.

- But for ink deposited on paper, the opposite situation holds: yellow ink *subtracts* blue from white illumination, but reflects red and green; it appears yellow.

1. Instead of red, green, and blue primaries, we need primaries that amount to -red, -green, and -blue. I.e., we need to *subtract* R, or G, or B.

2. These subtractive color primaries are Cyan (C), Magenta (M) and Yellow (Y) inks.



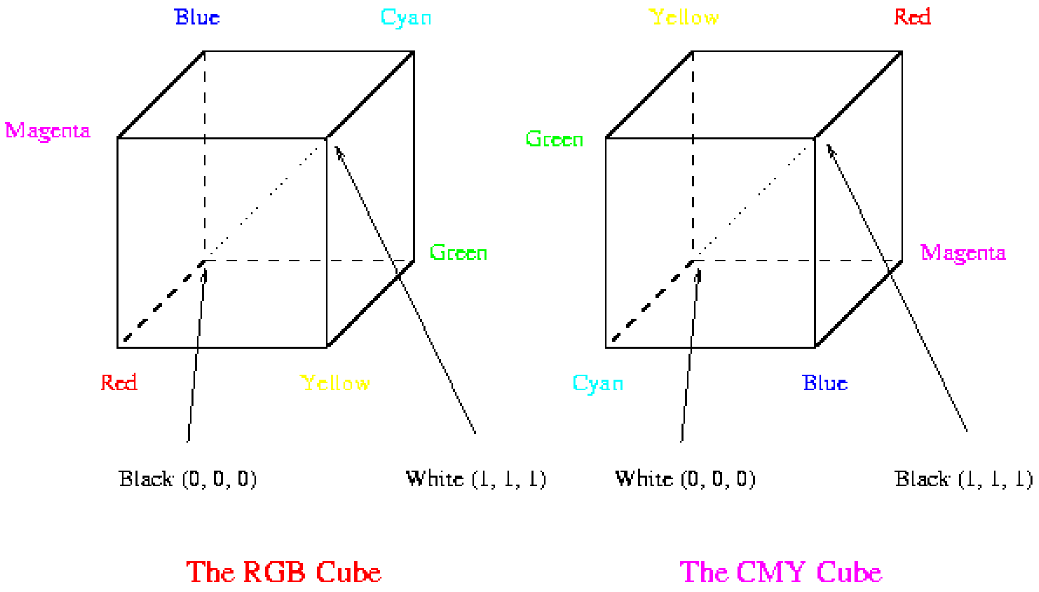
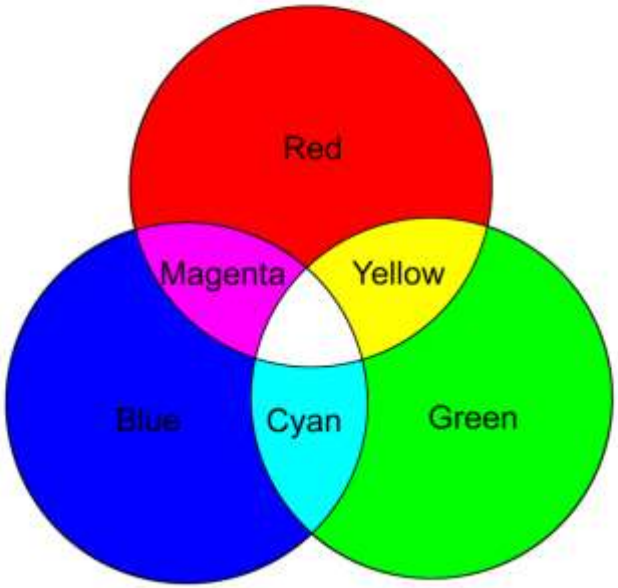


Fig. 4.15: RGB and CMY color cubes.

- Fig. 4.16: color combinations that result from combining primary colors available in the two situations, additive color and subtractive color.



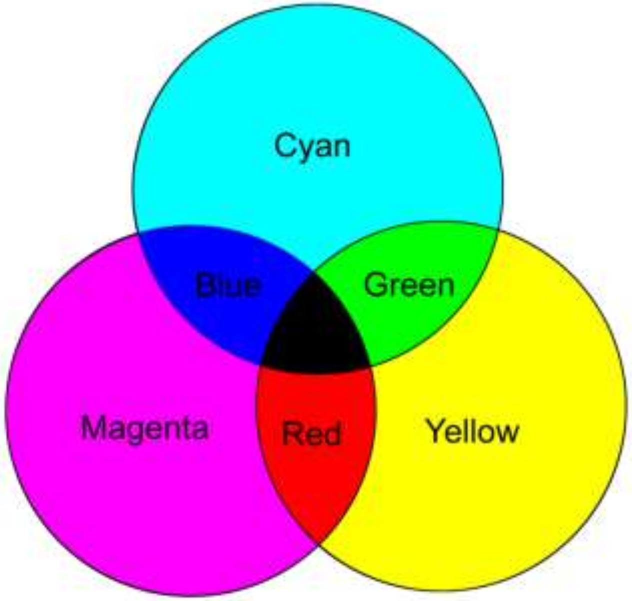


Fig. 4.16: Additive and subtractive color. (a): RGB is used to specify additive color. (b): CMY is used to specify subtractive color

Transformation from RGB to CMY

- Simplest model we can invent to specify what ink density to lay down on paper, to make a certain desired RGB color:

$$\begin{bmatrix} C \\ M \\ Y \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} - \begin{bmatrix} R \\ G \\ B \end{bmatrix} \tag{4.24}$$

Then the inverse transform is:

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} - \begin{bmatrix} C \\ M \\ Y \end{bmatrix} \tag{4.25}$$

Undercolor Removal: CMYK System

- **Undercolor removal**: Sharper and cheaper printer colors: calculate that part of the CMY mix that would be black, remove it from the color proportions, and add it back as real black.

- The new specification of inks is thus:

$$K \equiv min\{C, M, Y\} \qquad (4.26)$$

$$\begin{bmatrix} C \\ M \\ Y \end{bmatrix} \Rightarrow \begin{bmatrix} C-K \\ M-K \\ Y-K \end{bmatrix}$$