BENHA University

BENHA Faculty of Engineering

Electrical Engineering Department

Color Fundamentals

Group 6

Prepared by:

يوسف ابراهيم الطوخي

هشام عبدالله نور الدين

عبدالرحمن صابر عبدالفتاح

Directed by :

د / ايمن سليمان

COLOR FUNDAMENTALS

- **the use of color is important in image processing because: color is a powerful descriptor that simplifies object identification and extraction.**
- **humans can discern thousands of color shades and intensities, compared to about only two dozen shades of gray.**

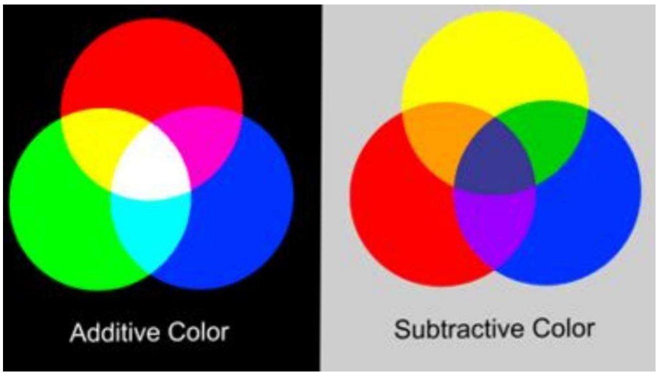
color image processing is divided into two major areas:

• Full-color processing:
images are acquired with a full-color sensor, such as a color tv camera or color scanner.

• Pseudocolor processing:
the problem is one of assigning a color to a particular monochrome intensity or range of intensities. color fundamentals colors are seen as variable combinations of the primary colors of light:
red (r), green (g), and blue (b).

- the primary colors can be mixed to produce the secondary colors: **magenta** (red+blue), **cyan** (green+blue), and **yellow** (red+green).

mixing the three primaries, or a secondary with its opposite primary color, produces white color however, the primary colors of pigments are cyan (c), magenta (m), and yellow (y), and the secondary colors are red, green, and blue. a proper combination of the three pigment primaries, or a secondary with its opposite primary, produces black.



- ***WHAT IS A COLOR MODEL?***

A color model is a system that helps us to define and describe colors through numerical values. There are many types of color models that use different mathematical systems to represent colors, although most color models typically use a combination of three or four values or color components.

- **Some popular color models used across the design industry are:**

1- RGB (Red, Green, Blue)
2- HSL (Hue, Saturation, Lightness)
3- CMYK (Cyan, Magenta, Yellow, Black)
4- CIE
5- Pantone® Color Reference Systems

- **WHAT'S THE DIFFERENCE BETWEEN A COLOR MODEL AND A COLOR SPACE?**

A color model is a system used to describe a color. For example with Red, Green and Blue (RGB) elements or Cyan, Magenta, Yellow and Black (CMYK).

A color space is a way of mapping real colors to the color model's particular values. For example, sRGB and AdobeRGB are color spaces that both use RGB as a color model, however the way they are displayed and represented will be slightly different.

1- RGB COLOR MODEL

The RGB model is used when working with digital screen based designs, such as those viewed on a computer screen or phone display. In the RGB color model, a value between 0 and 255 is assigned to each of the primary colors, Red, Green and Blue, where 0 is dark and 255 is bright. By listing the three values for the red, green and blue phosphors, you can specify the exact color that will be mixed.

The RGB color model is an additive color system, which means colors get lighter when mixed. As each component of light is mixed in, the combination becomes a new color. Red, green and blue are the three additive primaries. You can create any color within the constraint of the device using different combinations of the additive primaries. When you mix all three together in balanced amounts, you get white.

Television screens and computer monitors create color by turning on the red, green and blue primaries within each pixel. By changing each of the red, green, and blue primaries within a pixel to a different brightness, the monitor creates unique colors.

Because the RGB color model is only capable of producing a certain range (or gamut) of colors, there are some colors that cannot be reproduced accurately by a computer monitor. The number of colors visible on a monitor is further reduced by the limitations of the video hardware in the computer, which may display anywhere from just black and white up to 16.7 million colors.

2- HSL COLOR MODEL (HUE, SATURATION, LIGHTNESS)

The HSL model is very similar to the RGB color model. In fact, when they're expressed mathematically, they're identical. The difference lies in how colors are expressed numerically.

3- CMYK COLOR MODEL

The CMYK color model describes colors based on their percentage of Cyan, Magenta, Yellow and Black. Many computer printers and traditional "four-color" printing presses use the CMYK model. In the CMYK model, by mixing cyan, magenta, yellow and black inks or paints, you can create nearly any color desired.

In theory, you can mix any reflective color by mixing a combination of cyan, magenta and yellow alone. In the real world, however, the inks that printers use are not perfect. This becomes most obvious when you mix all three equally to make black. The color that results is muddy brown because the primaries overlap and don’t perfectly subtract light when mixed.

CMYK is a subtractive color model, which means colors get darker when mixed. Each of the mixed paints or inks absorbs different components of the light. If the right combination of paints is mixed together, all of the components of CIE COLOR SYSTEM (COMISSION INTERNATIONALE L'ECLAIRAGE)

4- PANTONE® COLOR REFERENCE SYSTEMS

The PANTONE MATCHING SYSTEM® is a solid color communication system based on the visual matching of individual, pre-mixed colors. The PANTONE MATCHING SYSTEM is a series of books with thousands of precisely printed colors alongside printers' formulas for mixing those colors.

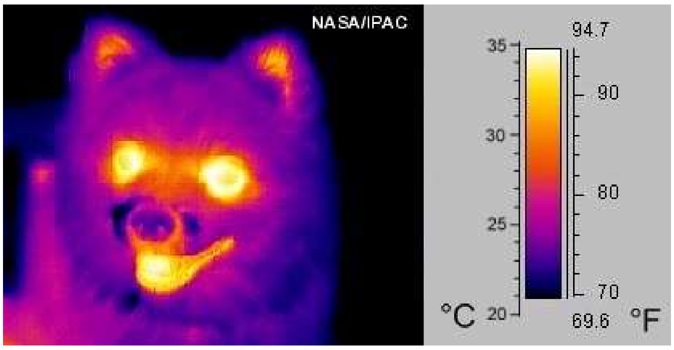
The PANTONE MATCHING SYSTEM is used by artists and commercial printers to select, specify and match colors very precisely. Many logos are created with specific PANTONE Colors that can be very closely reproduced. By using PANTONE Colors, designers can be confident that their output will match their expectations.

The original PANTONE MATCHING SYSTEM included 504 colors and has since been expanded to include 2,161 colors along with their printing ink formulations. For four-color (CMYK) printing, the PANTONE Process Color System® specifies 2,868 colors and shows the screen percentages for printing.

Recently, as computers have been used more extensively for business and professional graphics, software users have begun to specify their colors with the PANTONE MATCHING SYSTEM and the PANTONE Process Color System. More and more software products have been licensed by Pantone, Inc. to ensure a greater degree of consistency throughout the industry

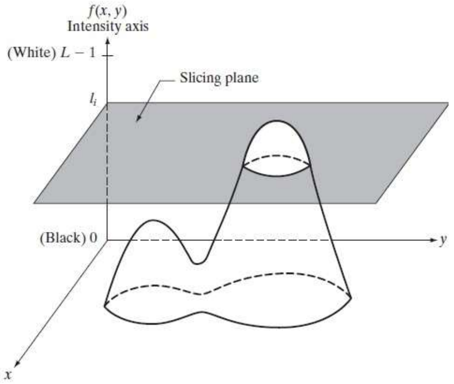
Pseudocolor images

are originally grayscale which are assigned colors based on the intensity values. Typical usage of these images is for thermography where the only available is infrared radiation instead of lights. Another example is elevation map.

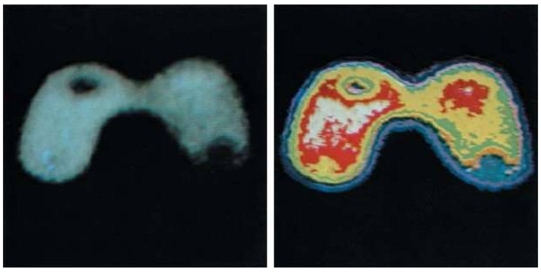


Intensity Slicing

This is a simple case of pseudocolor image processing. It's also called <u>density slicing or color coding.</u> Imagine a grayscale image as a 3D function with the intensity being the third dimension. Placing a plane parallel to the horizontal plane for the pixel position coordinates would *"slice"* the image into two parts. After that we can assign different colors to different levels.

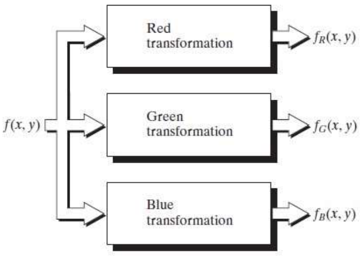


We are not constrained to use only one plane. Multiple slices result in more flexible representations of the grayscale images. In this case, the grayscale is parted into intervals and each one is assigned a different color.



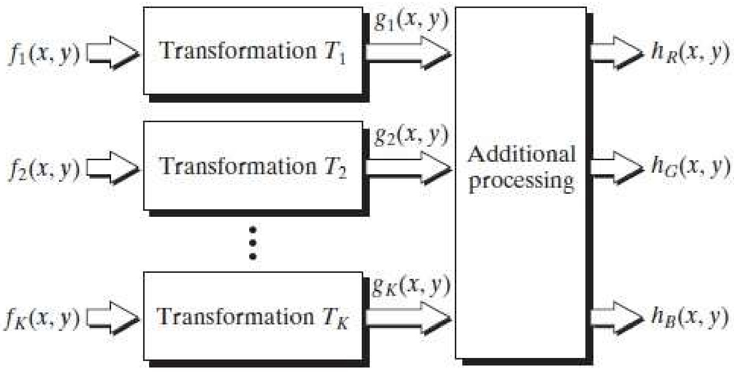
Intensity to Color Transformation

We can generalize the above technique by performing three independent transformations on the intensity of the image, resulting in three images which are the red, green, blue component images used to produce a color image.

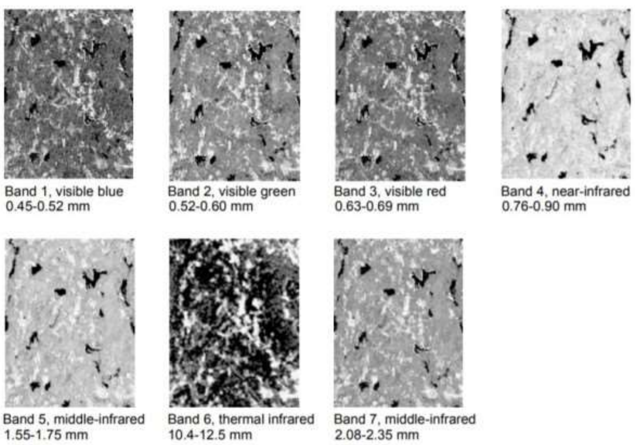


The flexibility can be even more enhanced by using more than one monochrome images, for example, the three components of an RGB and the thermal image.

This technique is called **multispectral image processing**



We often come across multispectral images *in remote sensing systems, for example, Landsat Thematic Mapper (TM) Band 7 which targets the detection of hydrothermal alteration zones in bare rock surfaces.*
Multispectral image processing allows us to infer the wavelengths that cannot be captured by the conventional RGB cameras or even



Band 1, visible blue 0.45-0.52 mm
Band 2, visible green 0.52-0.60 mm
Band 3, visible red 0.63-0.69 mm
Band 4, near-infrared 0.76-0.90 mm
Band 5, middle-infrared 1.55-1.75 mm
Band 6, thermal infrared 10.4-12.5 mm
Band 7, middle-infrared 2.08-2.35 mm

human eyes. This is an important technique for space-based images, or document and painting analysis.

Basics of Full-Color Image Processing

Full-color image processing approaches fall into two major categories:

- Approaches that process each component image individually and then form a composite processed color image from the individually processed components.
- Approaches that work with color pixels directly.

In full-color images, color pixels really are vectors. For example, in the RGB system, each color pixel can be expressed as

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

For an image of size $M \times N$, there are MN such vectors, $c(x, y)$, for $x = 0,1, 2,\ldots,M-1$; $y = 0,1,2,\ldots,N-1$.