

LEC 03

NATURE OF DIGITAL IMAGES

ENRICO G. DACANAY

BSCS
Comp Tech Dept



PRESENTATION OUTLINE



- Anatomy of Digital Image
 - Bitmap Image
 - Vector Image
- Bit Depth
- Image Size and Resolution
- Color
- Color Conversion
- Image Compression

BITMAP IMAGE



- Bitmap images, technically called raster images, use a rectangular grid of picture elements (pixels) to represent images. Each pixel is assigned a specific location and color value.
- A pixel is an individual square of colored light and is the smallest editable unit in a digital image.
- Bitmap images are resolution-dependent.
- The file sizes of bitmap images are usually quite large

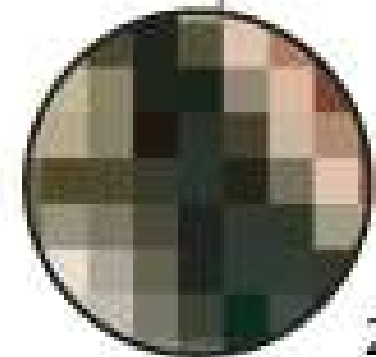
BITMAP IMAGE (CONT.)



- Example of a bitmap image at different levels of magnification



3:1



24:1

VECTOR IMAGE



- Vector graphics (sometimes called vector shapes or vector objects) are made up of lines and curves defined by mathematical objects called vectors, which describe an image according to its geometric characteristics.
- You can freely move or modify vector graphics without losing detail or clarity, because they are resolution-independent.

VECTOR IMAGE (CONT.)



- Example of a vector image at different levels of magnification



3:1



24:1

BIT DEPTH



- Bit depth specifies how much color information is available for each pixel in an image. The more bits of information per pixel, the more available colors and more accurate color representation.

BIT DEPTH (CONT.)



- A computer uses the binary number system to describe pixels. The simplest graphic images are 1-bit depth. In these files, only 1 binary digit of information describes the pixel: 0 for off, 1 for on. Each pixel is one of two colors, either black or white.

BIT DEPTH (CONT.)



- Grayscale and indexed color images use an 8-bit system, in which any pixel can be one of 256 shades of gray or color, respectively. Each pixel contains 8 bits of information. Each bit can be either on (black) or off (white), which produces 256 possible combinations ($2^8=256$).

BIT DEPTH (CONT.)



- Full color mages are 24-bit color, using three 8-bit primary color channels – for red, green, and blue – each containing 256 colors. These three channels produce a potential 16.7 million colors ($256^3=16,777,216$). Photo-realistic images that consist of smooth gradations and subtle tonal variations require 24-bit color to be properly displayed.

IMAGE SIZE AND RESOLUTION



- The pixel dimensions (image size or height and width) of a bitmap image is a measure of the number of pixels along an image's width and height. Resolution is the fineness of detail in a bitmap image and is measured in pixels per inch (ppi). The more pixels per inch, the greater the resolution. Generally, an image with a higher resolution produces a better printed image quality.

IMAGE SIZE AND RESOLUTION (CONT.)



- The combination of pixel dimension and resolution determine the amount of image data. Unless an image is resampled, the amount of image data remains the same as you change either the pixel dimension or resolution. If you change the resolution of a file, its width and height change accordingly to maintain the same amount of image data. And, vice versa.

IMAGE SIZE AND RESOLUTION (CONT.)



- Same image at 72-ppi and 300-ppi



IMAGE SIZE AND RESOLUTION (CONT.)



- You can't improve a lower-quality image by printing it at a high resolution. Changing the print resolution of an image simply makes each pixel larger, which results in pixelation—output with large, coarse-looking pixels. Increasing the print resolution of an image doesn't add any pixel information to the image. You can make a low-resolution image look its best by picking a print size that makes the most of the pixels it has.

SEATWORK: WRITE YOUR ANSWER IN A $\frac{1}{2}$ SHEET OF PAD PAPER.



- A photograph was scanned and resulted to a bitmap image having a width of 800 pixels and a height of 600 pixels. What will be the amount of storage space (in bytes) if it is saved in black and white? What if it is saved in grayscale mode? What if it is saved in a full color bitmap image?

COLOR (CONT.)



- Newton discovered that if a thin pencil of sunlight passes through a prism, the light spreads into an array of colors called a spectrum. Newton deduced that white light is a mixture of colored lights and these colored lights can be put back together to make white light again.



COLOR (CONT.)



- Color is the visual perceptual property corresponding in humans to the categories called red, yellow, blue and others.
- Color categories and physical specifications of color are also associated with objects, materials, light sources, etc., based on their physical properties such as light absorption, reflection, or emission spectra.

COLOR (CONT.)



- The science of color is sometimes called chromatics. It includes the perception of color by the human eye and brain, the origin of color in materials, color theory in art, and the physics of electromagnetic radiation in the visible range (that is, what we commonly refer to simply as Light).

COLOR MODEL



- A color model is an abstract mathematical model describing the way colors can be represented as tuples of numbers, typically as three or four values or color components.
- A color model is an orderly system for creating a whole range of colors from a small set of primary colors.
- A color model is simply a way to define color. A model describes how color will appear on the computer screen or on paper.

TWO TYPES OF COLOR MODELS



- Additive
 - Additive color models use light to display color.
 - Colors perceived in additive models are the result of transmitted light.
- Subtractive
 - Subtractive color models use printing inks.
 - Colors perceived in subtractive models are the result of reflected light.

ADDITIVE COLOR MODELS



- Additive primaries are the three colors of light (red, green, and blue) that produce all the colors in the visible spectrum when added together in different combinations.
- Adding equal parts of red, blue, and green light produces white.
- The complete absence of red, blue, and green light results in black.
- Computer monitors are devices that use the additive primaries to create color.

SUBTRACTIVE COLOR MODELS



- Subtractive primaries are pigments, which create a spectrum of colors in different combinations.
- Unlike monitors, printers use subtractive primaries (Cyan, Magenta, Yellow, and black pigments) to produce colors through subtractive mixing.
- The term “subtractive” is used because the primary colors are pure until you begin mixing them together, resulting in colors that are less pure versions of the primaries.
- For example, orange is created through the subtractive mixing of magenta and yellow together.

COLOR GAMUT AND COLOR SPACES



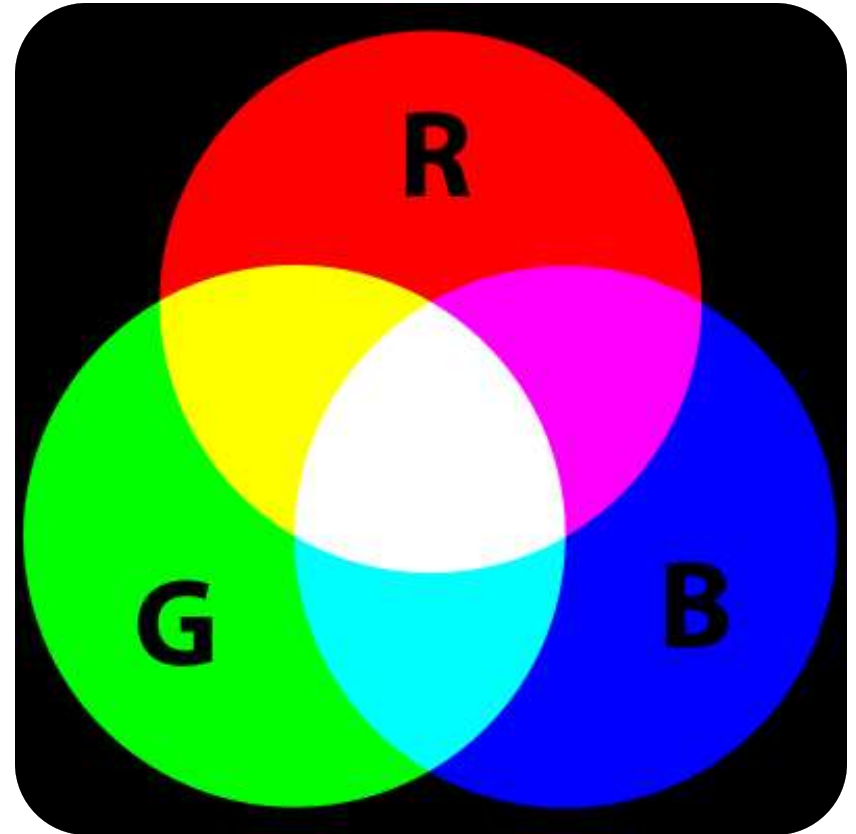
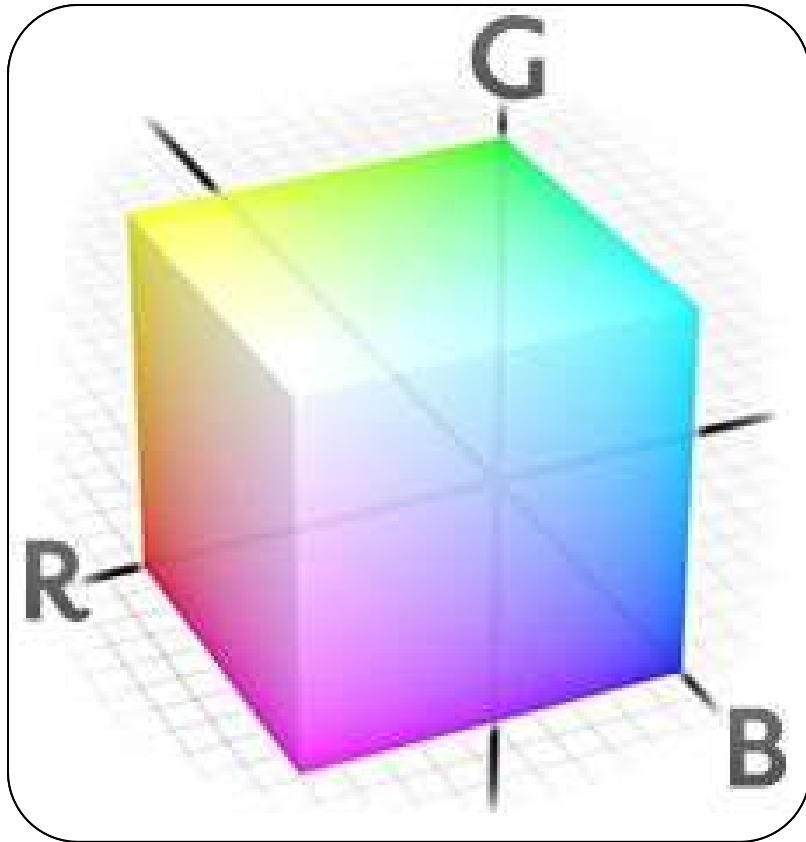
- Each color model has its own gamut (range) of colors that can be displayed or printed.
- Each color model is limited to only a portion of the visible spectrum.
- Since a color model has a particular range of available color or gamut, it is referred to as using a "color space".
- When a color model is associated with a precise description of how the components are to be interpreted (viewing conditions, etc.), the resulting set of colors is called a color space.
- A color space is one where the components of the color model are precisely defined, allowing viewers to know exactly how each color looks.

POPULAR COLOR MODELS



- RGB Color Model
- CMYK Color Model
- HSB Color Model
- CIE Lab Color Model

RGB COLOR MODEL



RGB COLOR MODEL



- Media that transmit light (cathode ray tube, LCD, plasma, and LED displays) use additive color mixing with primary colors of red, green, and blue, each of which stimulates one of the three types of the eye's color receptors with as little stimulation as possible of the other two. This is called "RGB" color space.
- Mixtures of light of these primary colors cover a large part of the human color space and thus produce a large part of human color experiences. This is why color television sets or color computer monitors need only produce mixtures of red, green and blue light.

RGB COLOR MODEL (CONT.)



- The intensity values range from 0 to 255 for each of the RGB (red, green, blue) components. For example, a bright red color might have an R value of 246, a G value of 20, and a B value of 50. When the values of all three components are equal, the result is a shade of neutral gray. When the values of all components are 255, the result is pure white; when the values are 0, pure black.

RGB COLOR MODEL (CONT.)



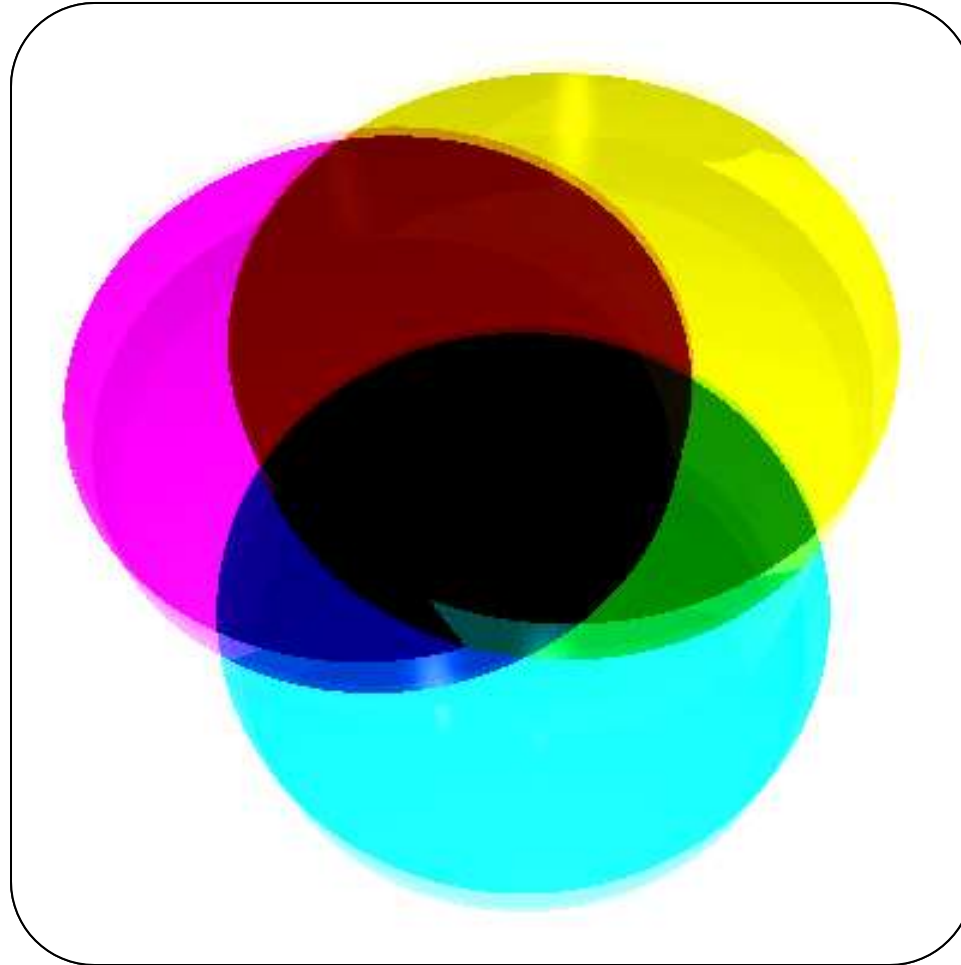
- RGB images use three colors, or channels, to reproduce colors on-screen. In 8-bits-per-channel images, the three channels translate to 24 (8 bits x 3 channels) bits of color information per pixel. With 24-bit images, up to 16.7 million colors can be reproduced.
- With 48-bit (16-bits-per-channel) and 96-bit (32-bits-per-channel) images, even more colors can be reproduced.

RGB COLOR MODEL (CONT.)

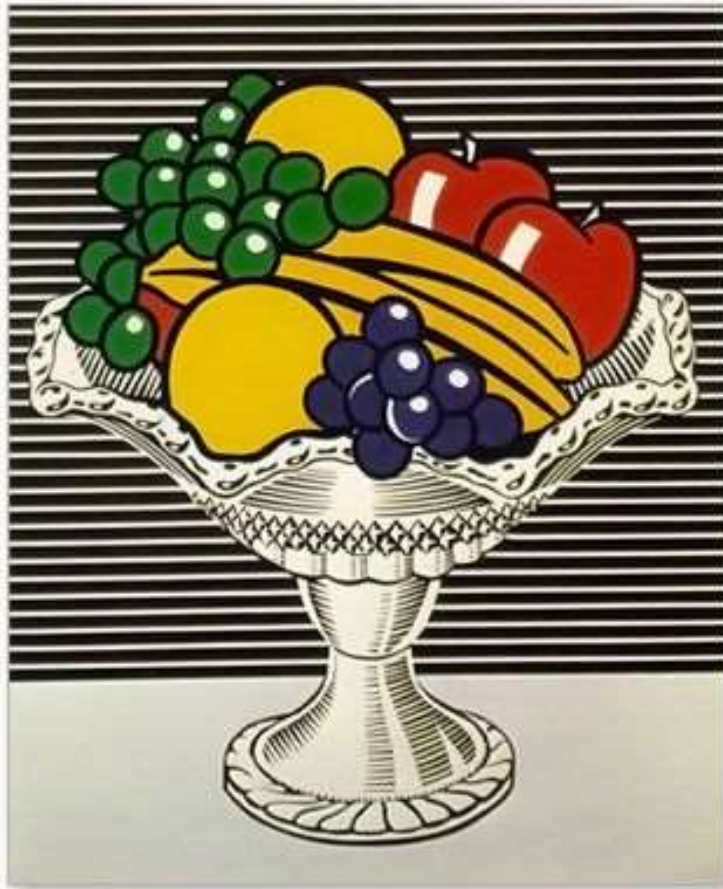


- In web page design, there are 216 so-called “web-safe” RGB colors represented by hexadecimal values. Today, RGB remains the color model and standard for HTML programming, but the prevalence of 24-bit displays allows most users to see 16.7 million colors of HTML RGB code.

CMYK COLOR MODEL



CMYK COLOR MODEL



Original painting



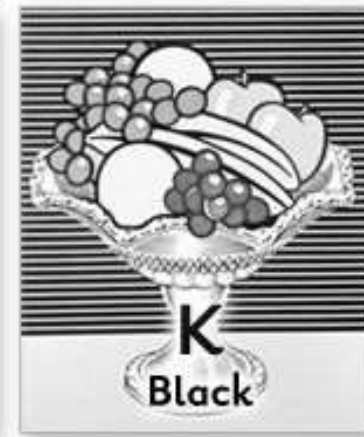
C
Cyan



m
Magenta



Y
Yellow



K
Black

CMYK Components

CMYK COLOR MODEL



- It is possible to achieve a large range of colors seen by humans by combining cyan, magenta, and yellow transparent dyes/inks on a white substrate. These are the subtractive primary colors. Often a fourth black is added to improve reproduction of some dark colors. This is called "CMY" or "CMYK" color space.

CMYK COLOR MODEL (CONT.)



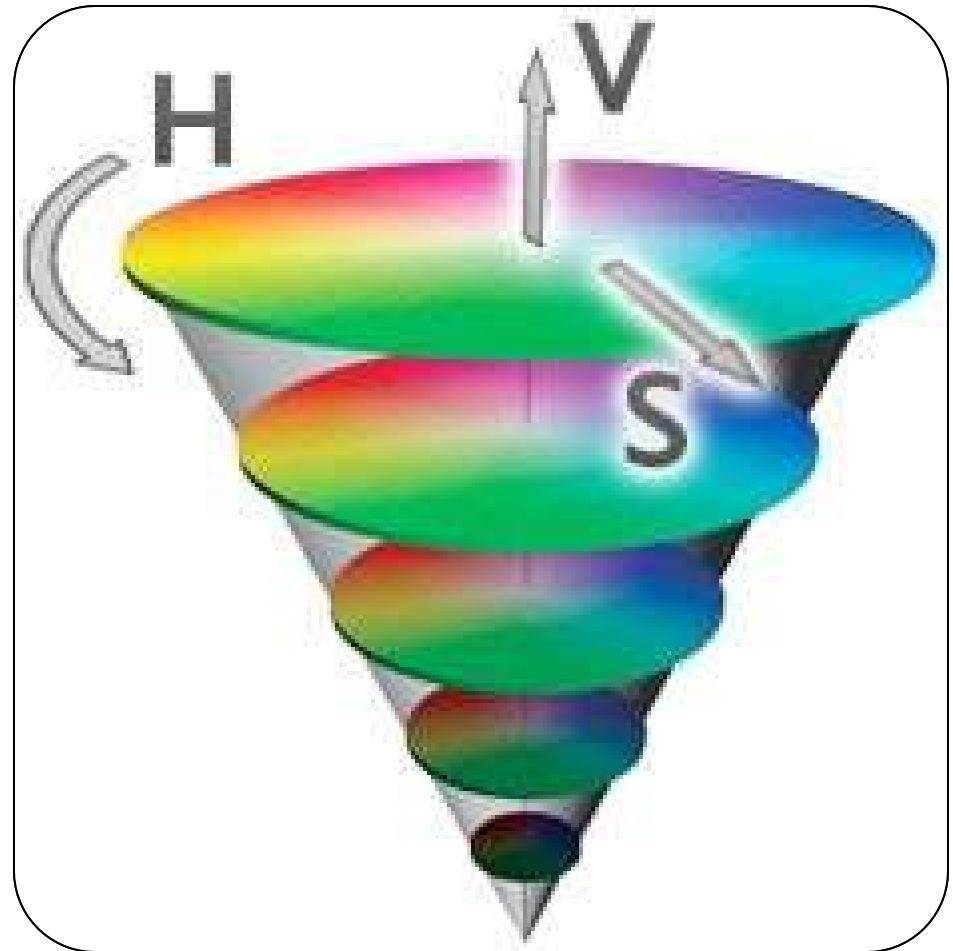
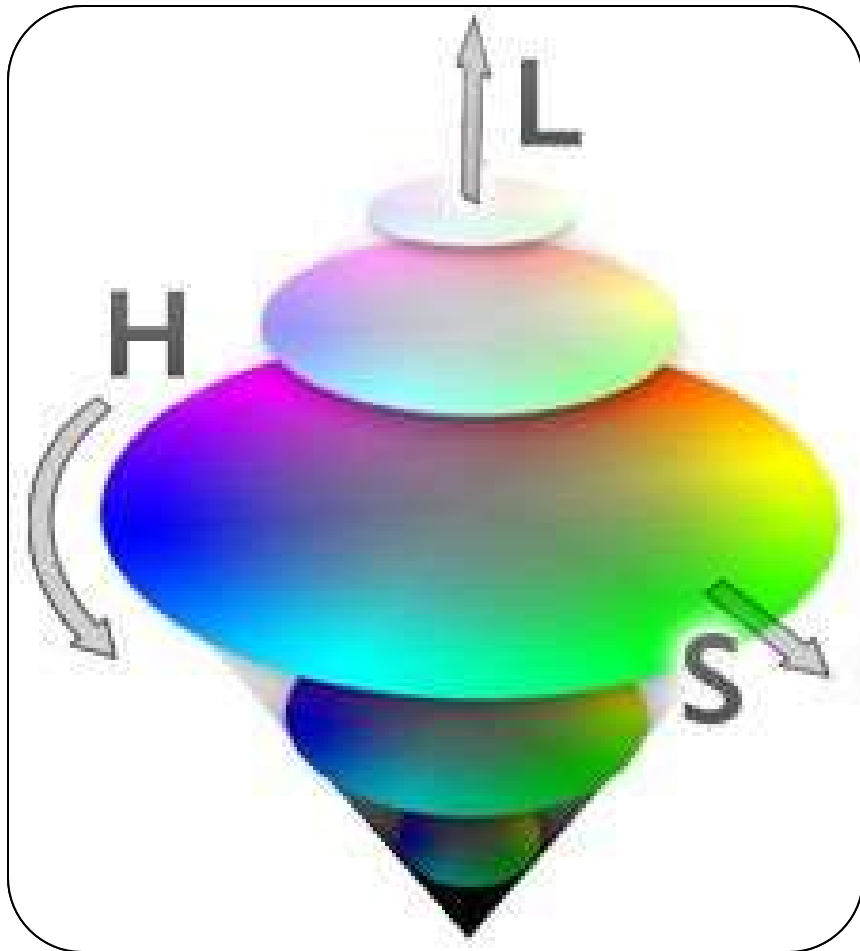
- The cyan ink will reflect all but the red light, the yellow ink will reflect all but the blue light and the magenta ink will reflect all but the green light. This is because cyan light is an equal mixture of green and blue, yellow is an equal mixture of red and green, and magenta light is an equal mixture of red and blue.

CMYK COLOR MODEL (CONT.)



- In the CMYK color model, each pixel is assigned a percentage value for each of the process inks. The lightest (highlight) colors are assigned small percentages of process ink colors; the darker (shadow) colors higher percentages. For example, a bright red might contain 2% cyan, 93% magenta, 90% yellow, and 0% black. In CMYK images, pure white is generated when all four components have values of 0%.

HSB/HSL/HSV COLOR MODEL



HSB/HSL/HSV COLOR MODEL



- Based on the human perception of color, the HSB/HSL/HSV model describes three fundamental characteristics of color: Hue, Saturation and Brightness or Lightness or Value

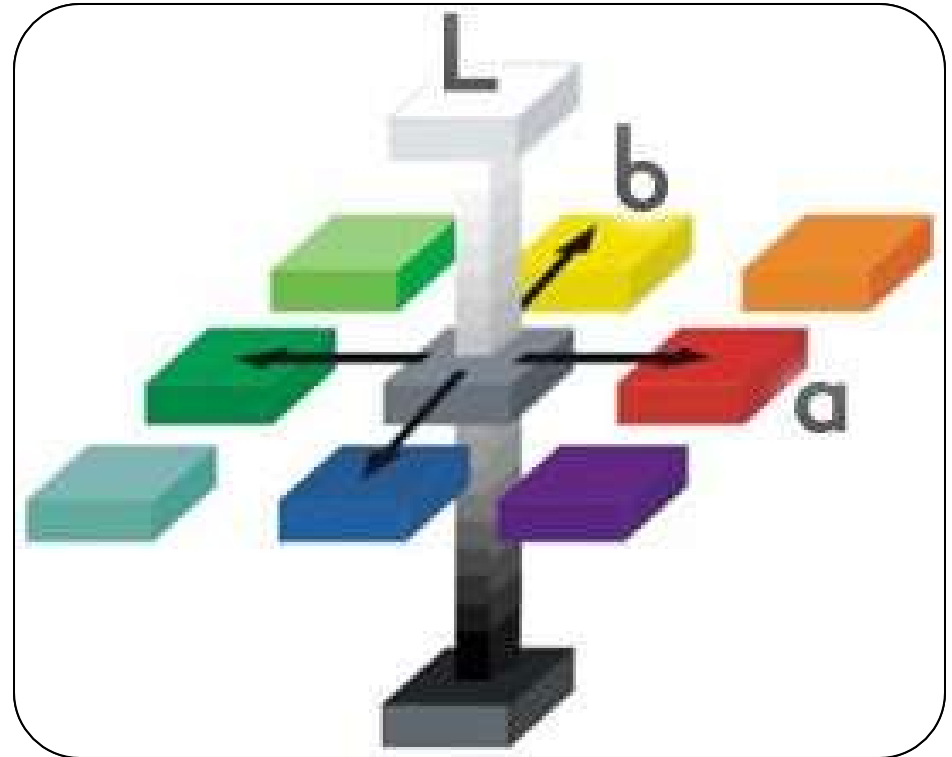
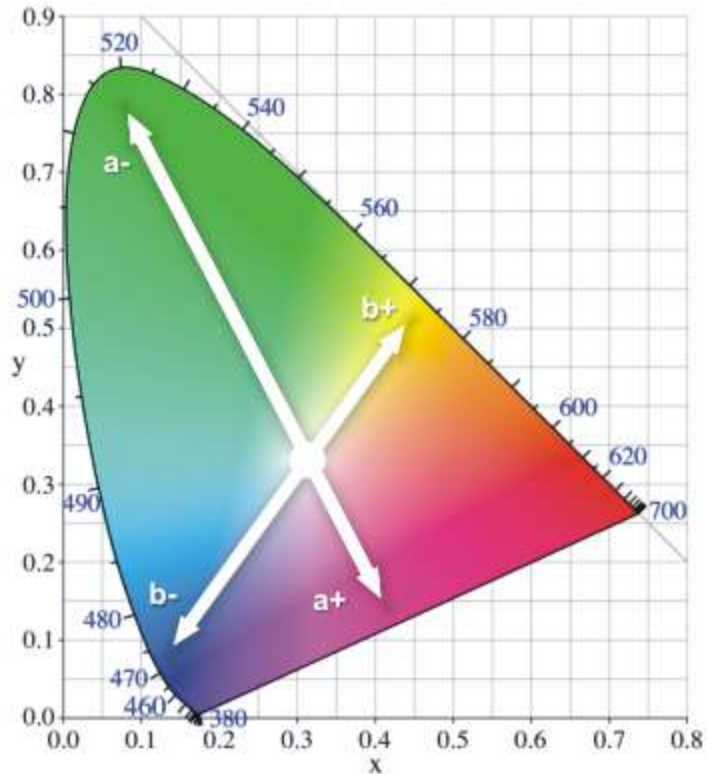
HSB/HSL/HSV COLOR MODEL

(CONT.)



- Hue - Color reflected from or transmitted through an object. It is measured as a location on the standard color wheel, expressed as a degree between 0° and 360° . In common use, hue is identified by the name of the color, such as red, orange, or green.
- Saturation - Strength or purity of the color (sometimes called chroma). Saturation represents the amount of gray in proportion to the hue, measured as a percentage from 0% (gray) to 100% (fully saturated). On the standard color wheel, saturation increases from the center to the edge.
- Brightness /Lightness /Value – Relative lightness or darkness of the color, usually measured as a percentage from 0% (black) to 100% (white).

CIE LAB COLOR MODEL



CIE LAB COLOR MODEL



- The CIE Lab color model is based on the human perception of color.
- The numeric values in Lab describe all the colors that a person with normal vision sees.
- Because Lab describes how a color looks rather than how much of a particular colorant is needed for a device (such as a monitor, desktop printer, or digital camera) to produce colors, Lab is considered to be a device-independent color model.
- Color management systems use Lab as a color reference to predictably transform a color from one color space to another color space.
- the mother of all color manipulation

CIE LAB COLOR MODEL



- The Lab Color mode has a lightness component (L) that can range from 0 to 100. In the Adobe Color Picker and Color palette, the a component (green-red axis) and the b component (blue-yellow axis) can range from +127 to -128.
- CIE stands for Commission internationale de l'éclairage or International Commission on Illumination. It was established in 1913 and based in Vienna, Austria. It is the international authority on light, illumination, color, and color spaces.

RGB TO CMYK CONVERSION FORMULA



- The R,G,B values are divided by 255 to change the range from 0..255 to 0..1:

$$R' = R/255$$

$$G' = G/255$$

$$B' = B/255$$

RGB TO CMYK CONVERSION

FORMULA



- The black key (K) color is calculated from the red (R'), green (G') and blue (B') colors:

$$K = 1 - \max(R', G', B')$$

- The cyan color (C) is calculated from the red (R') and black (K) colors:

$$C = (1 - R' - K) / (1 - K)$$

- The magenta color (M) is calculated from the green (G') and black (K) colors:

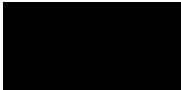







$$M = (1 - G' - K) / (1 - K)$$

- The yellow color (Y) is calculated from the blue (B') and black (K) colors:

$$Y = (1 - B' - K) / (1 - K)$$

EXAMPLE



Color	Color name	(R,G,B)	Hex	(C,M,Y,K)
	Black	(0,0,0)	#000000	(0,0,0,1)
	White	(255,255,255)	#FFFFFF	(0,0,0,0)
	Red	(255,0,0)	#FF0000	(0,1,1,0)
	Green	(0,255,0)	#00FF00	(1,0,1,0)
	Blue	(0,0,255)	#0000FF	(1,1,0,0)
	Yellow	(255,255,0)	#FFFF00	(0,0,1,0)
	Cyan	(0,255,255)	#00FFFF	(1,0,0,0)
	Magenta	(255,0,255)	#FF00FF	(0,1,0,0)

CMYK TO RGB CONVERSION

FORMULA



- The R, G, B values are given in the range of 0..255.
- The red (R) color is calculated from the cyan (C) and black (K) colors:

$$R = 255 \times (1-C) \times (1-K)$$

- The green color (G) is calculated from the magenta (M) and black (K) colors:

$$G = 255 \times (1-M) \times (1-K)$$

- The blue color (B) is calculated from the yellow (Y) and black (K) colors:

$$B = 255 \times (1-Y) \times (1-K)$$

EXAMPLE











Color	Color name	(C,M,Y,K)	(R,G,B)	Hex
	Black	(0,0,0,1)	(0,0,0)	#000000
	White	(0,0,0,0)	(255,255,255)	#FFFFFF
	Red	(0,1,1,0)	(255,0,0)	#FF0000
	Green	(1,0,1,0)	(0,255,0)	#00FF00
	Blue	(1,1,0,0)	(0,0,255)	#0000FF
	Yellow	(0,0,1,0)	(255,255,0)	#FFFF00
	Cyan	(1,0,0,0)	(0,255,255)	#00FFFF
	Magenta	(0,1,0,0)	(255,0,255)	#FF00FF

IMAGE COMPRESSION



- Image file formats are standardized means of organizing and storing digital images. Image files are composed of either pixel or vector (geometric) data that are rasterized to pixels when displayed (with few exceptions) in a vector graphic display.

IMAGE COMPRESSION (CONT.)



- Image file size – expressed as the number of bytes – increases with the number of pixels composing an image, and the color depth of the pixels. The greater the number of rows and columns, the greater the image resolution, and the larger the file. Also, each pixel of an image increases in size when its color depth increases—an 8-bit pixel (1 byte) stores 256 colors, a 24-bit pixel (3 bytes) stores 16 million colors, the latter known as true color.

IMAGE COMPRESSION (CONT.)



- High resolution cameras produce large image files, ranging from hundreds of kilobytes to megabytes, per the camera's resolution and the image-storage format capacity.
- For example, an image captured by a 12-MP camera in a true color mode:

12 million pixels *(3 bytes/pixel)

= 36,000,000 bytes

= 34 MB

IMAGE COMPRESSION (CONT.)



- Faced with large file sizes, both within the camera and a storage disc, image file formats were developed to store such large images.
- Image compression uses algorithms to decrease the size of a file.
- The overall results of the compression process, both in terms of storage savings - usually expressed numerically in terms of compression ratio (CR) or bits per pixel (bpp) - as well as resulting quality loss may vary depending on the technique, format, options, and the image contents.

TWO TYPES OF IMAGE COMPRESSION ALGORITHMS



- Lossless Compression
- Lossy Compression

LOSSLESS COMPRESSION



- Lossless compression algorithms reduce file size without losing image quality, though they are not compressed into as small a file as a lossy compression file.
- When image quality is valued above file size, lossless algorithms are typically chosen.
- Lossless compression should be preferred when dealing with line art, technical drawings, cartoons, etc. or images in which no loss of detail may be tolerable

LOSSY COMPRESSION



- Lossy compression algorithms take advantage of the inherent limitations of the human eye and discard invisible information.
- Most lossy compression algorithms allow for variable quality levels (compression) and as these levels are increased, file size is reduced.
- At the highest compression levels, image deterioration becomes noticeable as "compression artifacting".
- Lossy compression should be used for general purpose photographic images

MAJOR GRAPHIC FILE FORMATS



- BMP File Format (.bmp)
- Graphics Interchange Format (.gif)
- Joint Photographic Experts Group (.jpg, .jpeg, .jpe)
- Portable Network Graphics (.png)

BMP FILE FORMAT (.BMP)



- Also known as Windows Bitmap, it is the native image format in the Windows platform
- It is one of the simplest image formats and supports images with 1, 4, 8, 16, 24, and 32 bits per pixel.
- Typically, BMP files are uncompressed, hence they are large; the advantage is their simplicity and popularity and wide acceptance in Windows programs.

GRAPHICS INTERCHANGE FORMAT

(.GIF)



- GIF (Graphics Interchange Format) is limited to an 8-bit palette, or 256 colors.
- commonly used to display indexed-color graphics and images in Hypertext Markup Language (HTML) documents over the World Wide Web and other online services.
- The GIF format supports animation and is still widely used to provide image animation effects.
- It uses a lossless compression called LZW (Lempel-Ziv-Welch) data compression.
- GIF was originally devised by CompuServe in 1987

JOINT PHOTOGRAPHIC EXPERTS GROUP (.JPG, .JPEG, .JFIF)



- JPEG compression is lossy compression.
- Nearly every digital camera can save images in the JPEG format, which supports 24 bits per pixel, producing relatively small files.
- JPEG format is commonly used to display photographs and other continuous tone images in hypertext markup language (HTML) documents over the World Wide Web and other online services.
- JPEG format supports CMYK, RGB, and Grayscale color modes.

PORTABLE NETWORK GRAPHICS

(.PNG)



- The PNG (Portable Network Graphics) format was originally designed to replace the GIF format. It was created as the free, open-source successor to the GIF.
- PNG format is used for lossless compression and for display of images on the web.
- Unlike GIF, PNG supports 24-bit images and produces background transparency without jagged edges. PNG format supports RGB, Indexed Color, Grayscale, and Bitmap mode images.
- PNG preserves transparency in grayscale and RGB images.
- Many older browsers currently do not support the PNG file format, however, with Mozilla Firefox or Internet Explorer 7, all contemporary web browsers now support all common uses of the PNG format
- PNG is designed to work well in online viewing applications, such as the World Wide Web, so it is fully streamable with a progressive display option.