Computer Color Modes

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Just as different software applications are best for particular projects, there are different computer color modes that are best for particular images.

As you work in image editing and page layout applications, it's vital that you understand what the diffferent color modes are, which one is the right one for a particular image or project, and why some color modes creates file sizes that are much bigger that others. Understanding all this will help you avoid many problems later on.

The great thing about the basics of color technology is that it's one of the few standards on the computer, so understanding the color modes in general will help you in every program you use, as well as in printing color properly.

Bit depth

Before you can really understand all the color technology, you need to understand what **bit depth** is, also called *pixel depth* or *bit resolution*. You need to understand what it means when someone tells you it's an *8-bit image* or *24-bit image*. or when they talk about the limitations of a *16-bit monitor*. You can get away with knowing as little as this: **the higher the bit number, the more colors.**

Bit depth and file size

Logically, the deeper the bit depth, the more bits of information the computer has to send to each pixel, and thus the larger the file size. A big graphic, say 8x10 inches, with a deep pixel depth, such as 24-bit color, will take up many megabytes of space on your hard disk. But a 1-bit image at 8x10 inches takes up far less space.

(However, as you'll see later, bit depth is only part of what makes a file take up space. **Resolution** is another important part of the story.)

Bitmap color mode

The term **bitmap** refers to several things. In Chapter 4 you learned that image editing programs creat **bitmapped** images that you can edit pixel by pixel. When referring to color, though, **bitmap color mode** means the image is pure black and pure white. Period. Not even a single shade of gray.

A less ambiguous term for the bitmap color mode (because we can use "bitmapped" in other ways) is a 1-bit image, as I mentioned on the previous page. It's still "bitmapped" in the sense that you can edit the file in an image-editing program pixel by pixel –it's just that all of the pixels are either black or white. Think of art in the bitmap mode as the designs you could make on a kitchen floor with only black or white tiles.

My signature and some music scanned as 1-bit images. Both of these need only pure black and pure white to be properly displayed.

If you scan a 1-bit image, the scanner only captures black or white data. (Some scanner software calls this a newspaper mode.) I scan

My bank checks, mortgage statements, and telephone bills into images that I store on a backup disk. These images are saved as 1-bit images because I don't need to see those documents in color.

Geeky Stuff To Know About Bit Depth

The computer screen is divided into tiny little dots called **pixels**, pr picture elements. These pixels turn on or off (white or black), depending on the **bits of information** that are sent to them. Way back in 1985, pixels in computers weren't very smart. The monitors were called **1-bit monitors** because the pixels could only understand one bit of information at a time. With only one bit of information, a pixel could be one of two "colors"--it could be either white of black, on or off. Similarly, a 1-bit image consisted of only two colors. The artwork was either white or black, on or off.
Later, monitors and images got smarter. With a 2-bit monitor or a 2-bit image every pixel could understand two bits of information. With two bits of information sent to a pixel, that pixel could be any one of four "colors." It could have these choices: 11, 00, 10, or 01. In other words, both bits could be on; both bits could be off; one on one off; or one off and one on. One of these colors is black, one is white, and the other two are two shades of gray.
Today's 24-bit monitors and images can display millions of colors. The exact number is found by multiplying 2 times 2 a total of 24 times. This is called 2 to the 24th power, and is written mathematically as 2(24). That comes to 16,777,216. With over 16 million colors at hand, that is enough to simulate the number of colors in nature that the human eye can recognize.

Threshold

When you scan an image in the bitmap color mode, any gray tones (if there are any in the image) are converted to either black or white. If there are various shades of gray, the scanner evaluates how light or dark they are: If a gray is above a certain level, it's converted to black; if a gray is below a certain level, it's converted to white.

You can set the level to decide which grays are converted to black or white; this is called the **threshold**. *Lowering* the threshold means only the *darker* grays will convert to black; *increasing* the threshold means the *lighter grays* will also convert to black.

Grayscale mode

In the computer, **grayscale** is an **8-bit mode**, which means there are 254 different shades of gray, plus solid black and solid white, for a total of 256 different tones.

The concept of grayscale can be confusing because in our daily conversation we refer to grayscale images as "black and white." Think about the old photographs sent out by Hollywood stars in the thirties and forties. We call those pictures "black-and-white" photos, but they're not actually black and white –there are all sorts of gray tones in the photographs. These photos are actually grayscale.

Go back to the black-and-white kitchen floor we talked about earlier. Instead of just black or white tiles, this time you have 256 different shades of gray tiles. Obviously this lets you create much more subtle images.

What to scan as grayscale

It's easy to see that "black-and-white" photographs should be scanned as grayscale. But you should also scan as grayscale:

- Any type of “black-and-white” sketchy illustration that has shades of gray in it, such as pencil or charcoal sketches or wash drawings.

- Color photos or drawings that you’re going to reproduce in black and white, like on your laser printer or copy machine.

Do not scan as grayscale any line art images that need to have crisp edges. For instance, let’s say you see a great cartoon that you want to reprint in your company’s newsletter. (I won’t get into the legal issues of doing that here.) What you *don’t* want to do is print that cartoon as a grayscale image. Instead of the cartoon coming out nice and crisp, the edges will be slightly fuzzy and the lines will be shades of black, not pure black. This has been one of my biggest pet peeves when it comes to images in newspapers and magazines. Scanning line art images as grayscale makes it difficult to see small details in the image.

There are two ways to fix this problem. You can scan the cartoon as a 1-bit image with a high resolution (*covered later in Chapter 13*), or you can scan it as a grayscale image and then convert it to a high resolution 1-bit image.

Fortunately there have been enough people taking my classes to stop scanning cartoons incorrectly. And you, reading this book, will join that army of educated graphic designers.

The acronym **RGB** stands for **r**ed, **g**reen, and **b**lue. This RGB is the system monitors use to create color, using light. Monitors have three “guns” inside that “shoot” red, green, and blue light to every pixel on the screen. The computer blends these three light beams together in varying proportions to create the other colors you see. One hundred percent of all three colors produces white, which is why RGB is called an additive color model.

The cartoon on the left was scanned as a 1-bit image. Notice how the lines are pure black on a white background. Notice how the edges of the lines are crisp.

The same cartoon was then scanned as an 8-bit (grayscale) image. Look closely and you'll see how the top of the cash register is slightly shaded with fuzzy edges.

RGB mode

Scanners use RGB to capture color images. A scanner captures the varying levels of all the red, green, and blue data in an image. Each set of color information is called a **channel**. When the three channels of color are combined, the result is the full-color image.

Each of these RGB channels contains 256 shades of color. So there are 256 shades of red, 256 of green, and 256 of blue. Each channel is 8-bit, remember? The 3 channels put together create 24-bit color (3 channels times 8 bits).

Remember the kitchen tile floor? In an RGB analogy, it's as if there are three transparent "floors" (channels) overlapping each other. Each of the 256 colored tiles on one floor mixes with the colored tiles on the other floors. The combination of 3 different "floors," each with 256 levels of colors, allows for more than 16.7 million possible colors.

An RGB image is divided into three color channels: a red channel, a green channel, and a blue channel. Although shown here in colors, each channel is actually a grayscale image.

Choosing colors in RGB

You can never judge exactly what a color on the monitor will look like when it's printed on paper. Computer monitors use RGB; pages that are reproduced on a commercial press use CMYK colors (as discussed on the following two pages). There will always be a shift in colors from RGB to CMYK; it's physically impossible for them to appear exactly the same because they use completely different physics to display color (RGB uses light that goes straight to your eyes; CMYK uses reflected light bouncing off a physical object). Some colors shift quite dramatically when they're converted from RGB to CMYK.

You can choose RGB colors on the screen that are bright, vivid, and neon-like. But you'll be very disappointed when your final document is printed and all the vivid, neon colors print as ordinary, dull colors. Fortunately, some programs indicate which colors can't be printed in the CMYK process. These colors are called out of gamut, which in this case means they're out of the range of CMYK (I call them "illegal" colors). In some applications, out-of-CMYK-gamut colors are indicated by a little alert symbol, as show below. When you choose a color and see that alert symbol, it means the color you're seeing on the screen will be dramatically changed when it's converted to CMYK. Some programs let you click on the alert symbol to switch to the closest "legal" color, or you can adjust the color yourself until the alert symbol disappears.

Click the alert symbol to convert the selected color to the closest color that is within the CMYK gamut. Even if you print to any inkjet or specialty printer that uses red, green, and blue inks, the colors won't look exactly the same as they do on the screen, for the same physical reasons—light vs. reflection. Depending on the process, however, the RGB inks from a specialty printer will usually be closer to what you expect than they will be when printed to a commercial press using CMYK inks.

When you see the small alert symbol (circled), it indicates that the selected RGB color is out of the CMYK gamut and can't be converted to CMYK without shifting the color.

CMYK mode

The acronym CMYK stands for **c**yan, **m**agenta, **y**ellow, and a key color which is almost always blac**k**. The computer CMYK mode is used only for images that are going to be reproduced on a commercial press or on one of the specialty printers that requires CMYK, such as the Iris printer.

CMYK colors are also called **process colors**. Because the press uses these four inks to create all the colors an image needs, printing with CMYK is called **four-color printing**, or **process** printing.

The CMYK color model is based on what happens with light and objects out in the world, rather than in a monitor. A light source such as the sun or a light bulb sends white light down to objects around us; certain colors of the spectrum are absorbed by the objects and certain colors are reflected back to our eyes. For instance, when light hits a red apple, the apple absorbs (subtracts) all the colors of the light *except* the red, and the red is reflected into our eyes. In physics, this is called **subtractive** color model.

One hundred percent of cyan, magenta, and yellow creates (in theory) black. (Remember, in RGB one hundred percent of red, green, and blue creates white.)

Similar to RGB mode (and the kitchen floor analogy), there is a channel in image editing programs for each of the four transparent colors in CMYK mode. The channels show the amounts of each press color that will be printed. These are also called the **separations** for the image. The combination of all four channels is called the **composite** image.

A CMYK image consists of four color channels: cyan, magenta, yellow, and black. Each channel corresponds to the ink used is process printing.

Because there are four channels, you might think a CMYK image displays more colors than an RGB image in three channels, but the four channels don't actually change the number of possible colors. In fact, there are two important things to remember when working with CMYK color on the computer.

- The image you see on the computer is shown to you in RGB colors, be cause that's what the monitor does!
- The actual number of colors that can be printed using CMYK inks on paper is significantly less than 16.7 million anyway.

Choosing colors in CMYK

As I explained previously, there's a difference between color on a monitor and color on a printed page. In an image such as a photograph or a scan of a painting, there's not much you can do to the individual colors to ensure they print as particular CMYK colors. But often if a job is going to be printed in full color, you also want to set a headline in color, or perhaps some rules (lines) or a background color, or maybe you want to draw a simple illustration in color. Even if you're in your page layout application, you can create colors that will print as CMYK.

But rather than choose printed colors by what you see on the screen, you should get a **process color book** or **commercial color guide** from a company such as Pantone, Tru-Match, or Agfa. These guides are available at art stores, directly from the companies and their Web sites, or often from commercial print shops.

How to use a color guide to pick a color

The best way to choose a color isn't by looking at your monitor. That color won't necessarily be the same as the final printed product. The best way to choose a color is to first look at the printed process color guide and find a color that you like.

Next, write down the name of the color (if it's from a printed color book). Or write down the CMYK values listed next to that color.

Finally, look for the name of the color in the color picker o your software program. Many programs such as InDesign, Photoshop, Illustrator, and QuarkXPress contain libraries of various commercial color guide colors. So the same color you found printed in the color picker can also be found in the software. That way you know the values are correct.

Which modes for photography and scanning?

All digital cameras take photos in RGB color mode. When you scan a color image, you scan in the RGB color mode. Once you

The Index Color Mode

If you are familiar with a program such as Photoshop, you may have seen a color mode called Index Color. The index color mode is a deceptive type of color. Going back to the kitchen floor analogy, index color only has one floor, or channel, with 256 possible color tiles. But instead of limiting that channel to tints of the **same color**, the index color mode can have **many different colors** in one 8-bit channel.

Index color is rarely used in printed documents, but it is one of the most popular modes for images on the Web because you can limit the number of colors to just exactly the ones you need—fewer colors means smaller file sizes, which is always an objective in Web graphics. The most popular file format that uses the index color mode is the GIF file format.

The index mode is best used for graphics with broad areas of flat color.

Have the photo or scanned image, you can convert it into a CMYK file before you place it into a page layout application.

It's a good idea to keep the image in the RGB mode when working in image editing programs such as Photoshop or PhotoDeluxe for these reasons:

- RGB images are smaller than their CMYK equivalents, so RGB images will open and save faster than CMYK images.
- Some effects and filters in Photoshop or other programs are only available in the RGB mode.
- Converting back and forth between RGB and CMYK modes will cause some loss of information in the image. Make the conversion from RGB to CMYK the very last thing you do to an image.
- Ask the shop that will be doing the final reproduction (commercial press, specialty printer) for any specific settings they might want you to use when converting from RGB to CMYK.

Converting from color to grayscale

Consider if you take a picture with a digital camera and then want to print that image in a black-and-white newsletter or in the newspaper. The original photo is in color, but the final printed image needs to be grayscale.

You might think that moving down from three channels of information to one is very simple, but it's actually one of the trickiest parts of image manipulation. For years designers would choose the command to convert their image without realizing that the software was making the wrong decisions.

For instance, you may want the conversion from color to grayscale to highlight certain areas of an image. If you just apply the convert to grayscale command, some colors –especially reds and black –can become hard to distinguish.

Fortunately the Black and White conversion dialog controls in Adobe Photoshop make it easier to control the results when converting RGB to grayscale. Instead of simply choosing the grayscale mode, the Black and White dialog box lets you adjust the settings for how the red, green, blue, cyan, magenta, yellow, and black controls are converted. The result makes a much more vibrant grayscale image.

Another problem is that some designers who print to the black-and-white office printer don't even bother to convert their color images into grayscale. This results in a very muddy conversion when the image is printed. The bottom line is that you should take the time to modify a color photo into a proper grayscale image.

Color mode and depth chart

Use the following chart as a quick recap of the different color modes. And remember, the deeper the bit depth, the greater the file size.