

Computer Graphics 101 for Architects

There are two different ways computer programs store graphical information: ***bit-mapped*** and ***vector***.

1. CAD programs create images or files that are composed of vectors (a fancy word for lines).
2. Computer rendering programs create images or files that are bit-mapped (sometimes referred to as raster files).

Bit-mapped graphics differ from vector-based graphics in that they create images that are basically “dumb dots,” as opposed to lines, arcs, circles, or curves. Although bit-mapped files may look and print fine at high resolution, if the image is scaled up, pixilation may occur, resulting in an image that looks grainy and the edges of objects become stair-steppy or blurry. Vector-based files can be scaled up or down and look just as good as they did in its original size. Vector-based files also maintain a much smaller file size. Conversely, bit-mapped files increase in file size as they get larger or if the resolution increases.

Advantages of bitmapped images:

The ability to look “real” is the biggest advantage. Programs like Photoshop and other bitmapped image editing or paint programs are best used for the following purposes:

- Scanned photos, photo-montage images, and images with a artistic, hand-drawn, or painted look
- Photo-realistic images
- Scanned images used for underlays or for tracing, such as site plans, floor plans that you wish to trace over or use as a background for CAD drawings.

Advantages of vector-based artwork:

- CAD drawings where accuracy, scalability and reproduction is critical
- Graphic artwork like logos, posters, signs, etc.
- Large graphic images that need to have a small file size.

Bit-mapped Color Modes

A computer screen or a bit-mapped image is composed of a matrix of square dots called ***pixels***, short for picture elements (pix-els). Each pixel of a bit-mapped image has either 1, 8, 16, 24, or 32 bits of information per pixel. This number represents the amount or depth of color information that can be stored in each pixel.

The computers we use in our offices are called digital computers and all information they process, included graphic images, is translated into numbers. Thus, every pixel of color is a number. Bit depth refers to an image or the capabilities of a computer monitor to display colors. A bit, which stands for binary integer, is the smallest amount of information a computer can store, and is represented by either be a one or a zero. Digital computers use the ***binary*** (base 2) numbering system (compared to our usual base 10 numbering system) to store information, the

highest number that can be described with 8 ones or zeros is 256 (the binary number 11111111 = 256)

8 bit =	2 to the 8th power (2^8) =	256 simultaneous colors on a monitor/ 256 colors in an image's pallet
16 bit =	2 to the 16th power (2^{16}) =	32,000 simultaneous colors on a monitor/ 32,000 colors in an image's pallet
24 bit =	2 to the 24th power (2^{24}) =	16.7 million simultaneous colors on a monitor/ 16.7 million colors in an image's pallet

Each number therefore corresponds to what is called a *Color Look-up Table* (CLUT) for that image or computer display system. Eight bit images or computer displays set to 8 bit look pixelated or blotchy; 24-bit images have enough possibilities in their range of colors to look like a photograph.

Another phenomenon that occurs is when a 24 bit image is displayed on a monitor set for 8 bit pixel depth—the image is “dithered,” a trick that software plays to try to display colors that the monitor has not the depth to display. Dithered images often look crude and pixelated. Therefore, the goal is to have enough pixel depth in your image to look realistic and your monitor set to the proper pixel depth to make the images look good. These days, most systems are capable of displaying millions of colors, even on a 21 inch display. The ability to display 24 bit images is a function of how much video RAM (VRAM) your video card has and the *screen resolution* you monitor is set to (800 x 600, 1024 x 768, 1280 x 1024 are common screen resolutions). Note that each on these screen resolutions have a 4:3 “width to height” ratio, or what is known as the *aspect ratio*.

Bitmap

Each pixel contains one bit of information and two colors, black, or white (white = 0; black = 1). This mode is used for line drawings or scanned logos that are one color, with no grayscale.

Grayscale

Each pixel contains 8 bits of information that can display up to 254 levels of gray plus black and white, allowing images to look like black and white photographs.

Indexed Color

This color mode is used to get the image to conform to a pre-determined palette of color, usually to the Mac or Windows system palettes or to the standard Web palette. You can also create a custom “adaptive” color palette that derives from the image the best palette it can adapt from the image, given the pixel depth you determine, from 3 to 8 bit. Indexed color is used primarily for the web and multimedia to create the best looking color images while keeping file sizes at the minimum for easier downloads (internet) or quicker playback (multimedia).

RGB

This mode uses the Red, Blue and Green primary colors in combination to simulate true colors, giving us the possibility to create full color images. Each color contains 8 bits of color

information which equals 256 levels of lightness for that color, with black being the darkest and white being the lightest. Since there are three colors (or channels), each able to carry up to 256 levels of color information, then $256 \times 256 \times 256 = 16.7$ million possible colors that can be displayed in an image simultaneously. We can also say that's 28 for the red channel, 28 for green and 28 for blue which is $28 + 28 + 28 = 84 = 16.7$ million. Access to so many colors gives 24 bit images the color depth to look stunning.

This format can also be saved in 32-bit mode, or 4 channels per pixel. This allows for 3 channels to be used for color information in RGB format and a fourth channel can be used to store an *alpha channel*. An alpha channel is a grayscale channel with the pixel depth of 256. You can actually "talk" to this alpha channel in ArchiCAD (and other rendering programs) and tell it to change color, for example. In the materials dialog box, when you choose a texture pattern, you have an option of choosing a texture with an alpha channel, by enabling the alpha channel selection. Once a texture with an alpha channel is chosen for a material's surface, you can change the color of certain areas in the image, like the color of brick, while the mortar stays gray. RGB color images are used primarily for full-color images that will be viewed on the computer screen as slide shows, movies or multimedia.

CMYK Color

Similar to RGB, this mode has four channels of color: Cyan, Magenta, Yellow, and Black. These colors represent the four standard inks used in the printing process. In the print shop, these four inks mixed together can simulate true color. Note that not all RGB colors can be translated into CMYK colors. In Adobe Photoshop, you actually get an "out of gamut" warning when you are about to choose an RGB color that does not have a CMYK equivalent. CMYK mode is used primarily for color images that will be printed on a standard printing press.

Understanding Image Resolution

Understanding *image resolution* (not to be confused with *screen resolution*) is one of the most difficult things to grasp at first when learning about computer graphics and digital imaging (which is what rendering is all about.) Resolution simply means pixels per inch or ppi, Notice we did not say dpi, which is printer-related resolution. Images are composed of pixels while printers deliver their output in dots.

What you are going to do with the image will determine its resolution.

- for screen and multimedia presentations, use 72 ppi
- for print, you can use anywhere from 150 to 300 ppi, depending on the printer and printing process. Consult your printing service bureau or do some test prints on your office printer to determine "optimal resolution." Optimal resolution can be defined as the ppi to give you the image quality desired while keeping the ppi at a minimum. For each printer, there is a ppi point of diminishing returns, where adding ppi does nothing to enhance image quality and only increases file sized unnecessarily.

Understanding how image size, resolution in ppi, physical size, and file size interrelate is very important:

For computer-based slide shows and multimedia, the following resolutions are normally used in RGB mode:

- 640 x 480 @ 72 pixels per inch = 8.88 inches x 6.66 inches = 900k
- 800 x 600 @ 72 pixels per inch = 11.11 inches x 8.33 inches = 1.38 MB
- 1024 x 768 @ 72 pixels per inch = 14.22 inches x 10.66 inches = 2.23 MB

For printed images, the following relationships occur, using CMYK mode:

- 10 inches x 8 inches @ 150 pixels per inch = 1500 x 1200 pixels = 6.87 MB
- 10 inches x 8 inches @ 300 pixels per inch = 3000 x 2400 pixels = 27.5 MB
- 16 inches x 10 inches @ 150 pixels per inch = 2400 x 1500 pixels = 13.8 MB
- 16 inches x 10 inches @ 300 pixels per inch = 4800 x 3000 pixels = 55 MB

Understanding image file types

Understanding the alphabet soup of file types is very important in the world of computer graphics. How you save a file is called a *file format*. The most common file formats and their usage are as follows:

Extension	What It Means	What you use them for
Bitmapped file formats		
.tif	T agged I mage F ile F ormat	Images to be printed
.bmp	B it M apped File Format	Images for the screen
.jpg	J oint P hotographic E xperts G roup	Images for the screen or for sending via e-mail or posting on the Web
Vector file formats		
.eps	E ncapsulated P ost S cript	Line art, logos, posters. .eps files can be rasterized (turned into pixels) upon opening them in an image editing software like Photoshop
.dxf	D rawing E xchange F ormat	Universal file format for exchanging CAD files
.dwg	D rawing Format	Defacto format for exchanging CAD files (Autocad's native file format)