## Digital Imaging Basics

Digital data is a numeric representation of tangible information, whether it be the colors and shapes in a photograph, audio pitches and tones, text, numbers, calculations, graphic illustrations or combinations of them all.

In digital imaging applications, photographs are broken down into minute elements known as pixels. They are similar to the individual dots that make up a halftone for a printed photo. Pixels have also been likened to individual grains in silver-based film. Although the analogies are less than perfect, they do illustrate the concept in a way most photographers can relate to.

Each pixel is identified by its two dimensional location in the image and by the color it represents. The more pixels contained within an image, the greater the resolution and the more digital information available.

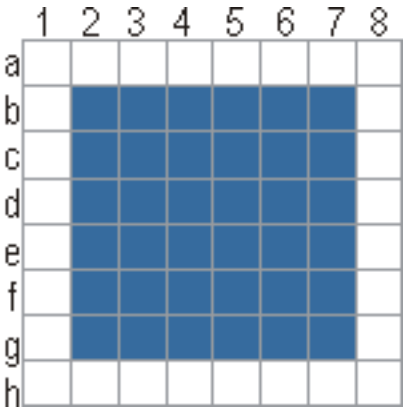
If a digital image contains only a few hundred pixels, the resolution will be quite low and the image may not even be recognizable. There is simply not sufficient information available for us to make sense of the result. Even with several thousand pixels, we still may not be able to recognize the image, but as we increase the number, we increase the resolution and detail that we can see.

## Vector and Raster Image Types

In most cases imaging programs are based in using one of two types of graphic types (not to be confused with file types). These are Vector images and Raster images (also know as bitmap images). The difference between vector and raster is a fundamental one. In raster format files, like GIF and JPG, the information is stored pixel by pixel. In the samples shown below, I have used very simple illustrations to show what is happening with each file type to place a gray rectangle on the page.

### Raster Image

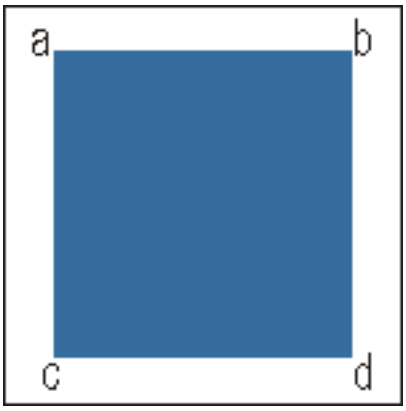
This example shows what is happening as raster file information is saved. Color/value information is given for each pixel in the image. Each square in the grid represents one pixel.




| **Pixel #** | **Color** |
|---|---|
| a1-a8 | white |
| b1 | white |
| b2-b7 | gray |
| b8 | white etc. ... |

Raster (Bitmap) images must store all the data for each pixel that represents the image. So, if you have a large image, you have many more pixels and much more pixel data, which results in a larger file. If you want the file to be smaller while the image remains the same size, you must discard some of the pixel data, which results in a loss of image quality.

**Vector Image**
Vector images, however, save information in a totally different way. In the sample below, I have used severely simplified language to illustrate how the exact same image would be described if it was a vector image.




**File information**
Draw a rectangular shape with coordinates at a, b, c, d and fill with gray.

Vector graphics are different from raster images in that vector graphics define images by assigning numbers—or vectors—to the various elements that make

up a *vector image*. Suppose that you open a drawing program and draw a stop sign. The drawing program stores the data that defines the image as numerical information about the placement, size, and shape of the octagon you draw, the lines that make up the letters in the word *STOP*, and even the colors that fill the octagon, the letters, and so on. As a result, this *vector graphic* drawing of a stop sign makes a smaller file than a *raster image* file of a color photograph of a stop sign, which must store all the data that would tell each pixel in the grid what color to be. You also can freely resize vector graphics up or down without a noticeable loss of quality, which cannot be said for bitmap images.

**Some Raster Programs**
Photoshop
PaintShop Pro
Corel PhotoPaint

**Some Vector Programs**
Illustrator
Freehand
CorelDraw
Fireworks
Flash

***Note**: Fireworks is an interesting hybrid of raster and vector types. Both Photoshop and PaintShop Pro have some vector capabilities, but since the saved files are raster format, they really should be considered raster-only programs.*

**Some Raster File Types**
GIF
JPG
PNG *
TIFF
BMP
PSD (Photoshop)

*PNG is technically a raster format, but when saved as the native Fireworks format, vector information is retained.

**Some Vector File Types**
AI (Adobe Illustrator)
FH (Freehand)
CDR (CorelDraw)
EPS (Encapsulated PostScript)

## Pixels and Image Resolution

When dealing with digital images you have to consider several aspects of the image that relate to its quality both on the screen and in printed form. This is generally related to the issue of resolution. **Simply put, *resolution* is the display quality of the image, regardless of the medium.** When dealing with resolution there are three different aspects that one needs to consider: Image Resolution, Monitor Resolution and DPI.

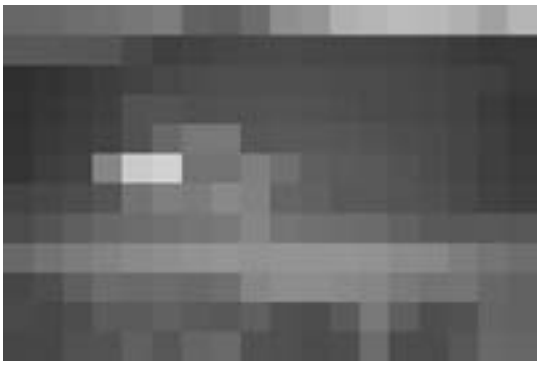
**Image Resolution**
The size of the digital image is specified by its dimension in pixels or by the total number of pixels it contains. Therefore display quality of an image is determined by the amount of pixel data that it has. More pixel data means higher quality. So, higher quality images have more pixel data, and image files with more pixel data are larger. The sharpness and clarity of on-screen and printed images and the size of image files are both related to resolution. Resolution can be originally specified by the amount of information that is either gathered during the original scan or set by the user during creation of a new file. After that, you can alter an image's resolution by changing it, using Photoshop's Image Size command.

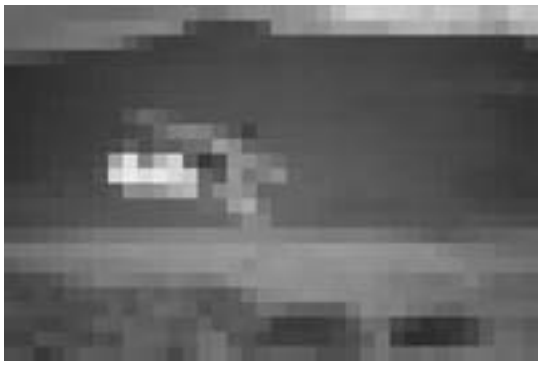
**Monitor Resolution**
The resolution of a display monitor is the screen's width and height in pixels. For example, a monitor may be specified as being 640 x 480, 800 x 600, 1024 x 768, and so on. The first number is the number of pixels across the screen. The second number is the number of rows of pixels down the screen. Most monitors are 72 dpi.

**DPI**
Resolution, which is measured in *dpi* (dots per inch) or sometimes *ppi* (pixels per inch), determines how large or small an image can be displayed or printed while maintaining image quality. "Dots per inch" means just that. It's the number of dots—pixels—that a digital image has in every inch, to represent the colors and lines and details of an image.

Do not confuse dpi with lpi. The term *dots per inch* refers to scanning resolution or image resolution, whereas the term *lpi* (*lines per inch*) refers to the halftone screen density specified for printing an image on a press or printer.

400x267 pixels of 8-bit grayscale = 104 Kilobytes or 104K


12x18 pixels grayscale = 216 bytes


24x36 pixels grayscale = 864 bytes


48x72 pixels grayscale = 3.4K


96x144 pixels grayscale = 13.5K

**Bit Depth**
A raster image's pixel information—what color each pixel should be—and the location on the grid of that pixel constitute the stored data of the raster image file.

This pixel data directly affects the size of the image file, according to how many bits of information are stored for each pixel. In Photoshop, each pixel can have as many as 64 bits of color information stored for it. A *bit* is the individual digit of binary code, either a zero or a one—which, in the case of computer graphics, could refer to on or off. If a pixel has a bit depth of one, the pixel will be either fully illuminated (on) or not illuminated (off ). Thus, one bit has two values (on or off ) or in the case of computer graphics, two colors. If you can follow that description, then you know that an 8-bit image has 256 colors. If you can't follow that thinking, here's the math:

**1-bit = 2 values = 2 colors**

**8-bit = 2 values x 2 values x 2 values x 2 values x 2 values x**
**2 values x 2 values x 2 values = 256 values = 256 colors**

The number of bits stored for each pixel determines a file's *bit depth* (sometimes also called either *pixel depth* or *color depth*) and directly affects the quality of the representation of color in the image.
Therefore a file with a higher bit depth can more accurately represent color than a file with a lower bit depth.

Full grayscale: 8-bit black - 256 levels

1-bit black: 2 levels

2-bit black: 4 levels

3-bit black: 8 levels

4-bit black: 16 levels

Now, depending on the color mode for a file you have what are called color *channels.* Think of channels as individual files for each color of the mode. For example, if you are working with an RGB file, which represents its range of color by using mixtures of red, green, and blue, you have three files—or channels—each one storing the pixel information for one of those colors. These three files are synchronized so that they display their individual pixels in the appropriate place on the grid for that file. As a result, they combine their colors to display the image accurately. Each channel stores the level of its particular color—the shade of that color— to illuminate for each pixel on the grid. That shade is determined by the pixel's bit depth.
Consider these examples:

1. Bitmap mode images are black-and-white images with no shades of gray. They have a bit depth of one, and they are known as 1-bit files because they have only one channel, or color, and they store only one bit of information about each pixel. That one bit is on or off—white or black. This type of file usually is reserved for black-and-white line drawings, sketches, and other high-contrast images that have no shades of gray.

2. The 8-bit grayscale images are black and white with 256 shades of gray. Remember the bit depth math? Because a grayscale image shades only one color, a grayscale image needs only one channel. Therefore, it is an 8-bit file.
3. All 24-bit RGB images are full-color images that mix three colors to represent 16.7 million colors. Think of it—16.7 million colors! The 24 in 24-bit comes from the three 8-bit channels (one 8-bit channel for red, one 8-bit channel for green, one 8-bit channel for blue, or 3 ´ 8 = 24). Each of those three 8-bit channels has 256 shades of its specific color. Those three channels, then, combine for the 16.7 million possible colors (256 ´256 ´ 256 = 16,777,216).

**File Size and Resolution**

To reduce that file's size, you have to throw away a bunch of pixel data. If you do so, you don't have as many pixels representing the same colors and shades of colors, so the resolution—the image quality—goes down. On the other hand, suppose that you have an image with a low resolution— say, 72 dpi. If you want to increase the dpi to 266, while leaving the image the same size, you can use the Image Size command. However, if you use this command, Photoshop has to fill in all those extra, new pixels by guessing— interpolating—what color they should be. Consequently, you lose image quality. Imagine, on the other hand, that you want to change that image's file size, and you intend to reduce its reproduction size at the same time. You can do so without losing image quality because you use the same number of pixels to represent the image. What this description boils down to is that, to retain optimum resolution, you should reduce an image's pixel data only if you are also reducing its size. If possible, scan at the highest possible resolution, and then reduce images down to whatever size you need. In general, the larger a digital file is, the more detail it contains and the larger it can be successfully reproduced.

For more information on imaging basics see:

**http://www.tasi.ac.uk/advice/using/basics.html**

**http://www.macwrightstudio.com/resourceArt/di_basics.html**

**http://swehsc.pharmacy.arizona.edu/exppath/micro/digimageintro.html**

## Common File Types for Digital imaging

**Background**
During the early years of computer graphics development and the race for dominance by both hardware and software manufacturers, many proprietary formats were designed. Every graphics program saved files in its proprietary -- or native -- format, and therefore, any file saved from a specific application and used exclusively by that application was -- and still is -- known as a native file. Unfortunately, these native files weren't always readable by other applications, especially when the native file was originated in a Mac-based application and the target application was PC-based or vice versa. With greater demands for inter-application compatibility and cross-platform compatibility, many developers and manufacturers realized that survival was closely linked to meeting those demands. Today, most major graphics applications can save and open both in their native formats and in a number of other formats that can be used to transfer images from one application to another or from one platform to another.

## Basic Image File Types

### The TIFF File (.tif)

TIFF -- or Tag Image File Format -- was developed by Aldus Corporation in 1986, specifically for saving images from scanners, frame grabbers, and paint/photo-retouching programs. Today, it is probably the most versatile, reliable, and widely supported bit-mapped format. It is capable of describing bilevel, grayscale, palette-color, and full-color image data in several color spaces. It includes a number of compression schemes and is not tied to specific scanners, printers, or computer display hardware. The TIFF format does have several variations, however, which means that occasionally an application may have trouble opening a TIFF file created by another application or on a different platform.

### The PICT File (.pict)

The PICT format -- which is not an acronym -- is native to the Macintosh. It first appeared in 1984 with the introduction of MacDraw software. Since then, it has been used by many applications, especially when images are designed for screen previews. It is great for presentations, screen displays, and video work. The PICT format can contain both bit-mapped and object-oriented graphics. It is a standard format for graphics that are cut or copied to the Clipboard and for drawings that will be output on raster printers.

### The EPS File (.eps)

EPS -- or Encapsulated PostScript -- files are the standard format for storing high-resolution PostScript illustrations. The EPS format -- which was introduced in the mid-'80s allows both Mac and Windows users to save bit-mapped screen representations of screen images. These previews, however, don't travel well across platforms. An EPS file generally has two parts: a PostScript (text) description that tells a PostScript printer how to output the resolution-independent image, and (optionally) a bit-mapped PICT image for on-screen previews. A drawing saved in EPS format can be imported into other documents and scaled and cropped, but its contents are often no longer editable, even by the program that created it (Adobe Illustrator files are the exception).

**The GIF File (.gif)**

GIF -- or Graphics Interchange Format -- files define a protocol intended for the on-line transmission and interchange of raster graphic data in a way that is independent of the hardware used in their creation or display. The GIF format was developed in 1987 by CompuServe -- one of the world's most successful bulletin board services -- for compressing eight-bit images that could be telecommunicated through their service and exchanged among users. The GIF file is defined in terms of blocks and sub-blocks that contain relevant parameters and data used in the reproduction of a graphic. A GIF data stream is a sequence of protocol blocks and sub-blocks representing a collection of graphics.

**The JPEG File (.jpg or .jpeg)**

JPEG is a standardized image compression mechanism. The name derives from the Joint Photographic Experts Group, the original name of the committee that wrote the standard. In reality, JPEG is not a file format, but rather a method of data encoding used to reduce the size of a data file. It is most commonly used within file formats such as JFIF and TIFF. JPEG File Interchange Format (JFIF) is a minimal file format that enables JPEG bitstreams to be exchanged between a wide variety of platforms and applications. This minimal format does not include any of the advanced features found in the TIFF JPEG specification or any application specific file format. JPEG is designed for compressing either full-color or grayscale images of natural, real-world scenes. It works well on photographs, naturalistic artwork, and similar material, but not so well on lettering or simple line art. It is also commonly used for on-line display/transmission; such as on web sites. A 24-bit image saved in JPEG format can be reduced to about one-twentieth of its original size.

**The Photoshop File (.psd)**

A Photoshop file is the native file format for Adobe Photoshop. A file saved in this manner can only be opened and edited in Photoshop. However, the

user has the option to save the file in a variety of other formats that are readable in both the Macintosh and PC environment. The major advantage of the Photoshop format becomes apparent when working on documents with layers. For example, a background can be created on one layer, then graphics can be added on a second layer, a drop-shadow on a third layer and text on yet another layer. Each layer is independent of the others and can be edited separately without affecting the contents of the other layers. Photoshop supports the preservation of layer information, so that the layers can be preserved for additional editing.

For more information on file formats for images see:

**http://www.scantips.com/basics09.html**

**http://www.simplythebest.net/info/imagefm.html**

**http://www.library.cornell.edu/preservation/tutorial/presentation/table7-1.html**

**http://graphicssoft.about.com/cs/graphicformats/**

**http://www.ace.net.nz/tech/TechFileFormat.html**