

[Note: I've used versions of this essay in all my digital photography and digital art courses for several years.]

# DIGITAL FUNDAMENTALS

## Characteristics of Digital Pictures

This handout discusses basic ideas about how pictures on the computer are described and used.



*What is a pixel?*

Pictures displayed on a computer are built of pixels (from “picture element”). If viewed individually on screen, a pixel appears as a square of light. The illusion of a coherent picture is produced when millions of pixels are combined into a grid and viewed from the correct viewing distance.

Pixels are not physical, not tangible; they have no substance; pixels are pure mathematics; pixels can't be seen (except on a computer) and pixels can't be touched. In other words, no one ever stubbed a toe on a pixel.

As a point of reference: hold a newspaper or magazine picture close to your eyes—the photograph disintegrates into the halftone dots of the printing process. Hold it at arm's length, however, and the dots become a picture that makes sense. The correct viewing distance, aka the *resolving distance*, for this kind of picture is intuitive—you *simply move the newspaper closer or farther from your eyes until it looks like a picture*.

A similar thing occurs with mosaics: like the printed image, though usually larger and composed of bigger elements—such as ceramic or glass tiles—mosaics require that we

actually move our whole bodies closer and/or farther from the grid in order to see the picture. Nevertheless the similarity is apparent: pictures in magazines, newspapers and pictures made with mosaics are built on the same principle as pictures made of pixels—i.e., viewing resolution. That is, in order for a digital picture to make sense, its pixels must be arranged and viewed from the proper distance.



Pixels, however, are fundamentally different from anything we experience in daily life. Unlike the pieces of a mosaic or the ink dots in a magazine, a pixel has no physical presence—it's not a spot, dot, slice, or chunk of anything. Rather, a pixel is an abstract construct created by the computer when it “reads” a string of binary numbers.

For example <0.1.1.1.0.0.0.1> might define a flesh colored spec of light at the tip of someone's nose—when it's displayed on a computer. Outside of the computer, however, this string of binary numbers has no meaningful reality.

*Every characteristic of the digital picture follows from its nature as a grid of pixels (aka pixel map, bitmap, or raster image).*

**Key ideas:**

Pixels are bright small squares.

A digital picture is a grid of pixels displayed on a computer screen.

Pixel grids are known as bitmaps, or raster images.

Pixel grids must be viewed at the correct display resolution or they will appear distorted and non-photographic, aka, pixelized.

## FIVE KEY CHARACTERISTICS

**1. Size of the Digital Image:** There are three different ways to discuss the size of a digital picture. None of them are equivalent to each other. In other words, when inquiring about the size of a digital picture, you must first understand whether you need to know, a) how much digital data the displayed picture is comprised of? or, b) the size of a print of the picture? or, c) the amount of disc space required to save the picture on a computer?

This is the first, most fundamental characteristic that you must become comfortable with: *size matters*, and there are *three ways to measure size*.



A) **Pixel Dimensions:** Width x Height in pixels. For example, 3008 x 2000, or 800 x 640. (Sometimes expressed as the amount of computer memory required to display the image, for example, K or M or G.) *How much data does the picture contain?* A picture displayed on a computer takes the shape of a rectangle. This rectangle is a grid, or a map – a coordinate system based on how many pixels wide and high the picture is. Consequently, each and every pixel in the picture has a definable address on the grid. Because of this, “pixel dimensions” is a precise and specific measurement of the size of a digital image. In fact, “pixel dimensions” is the only way to fundamentally describe the size of a digital image. This is because a digital picture can be displayed, or printed, or at any desired size. Note: A digital picture has no real-world analogue. It is, purely and simply, a grid of pixels.

B) **Document Size:** Width x Height x Display Resolution. AKA Print Size. To display

a digital image, a specific resolution (pixels/inch) must be applied to the pixel dimensions. If you are asking – *how big is that print?* or, *what size frame do I need in order to put that picture on the wall?* – then you are asking about Document Size. A digital image (pixel dimensions) can be printed at any document size, but the resolution of the output strongly affects the appearance of the print. (The relationship between pixel dimension and optimum print size is rather complicated and very dependent on the type of printer, or output device.

Note: Photoshop uses the label “document size” to mean “print size” or “output size”.)

- C) File Size on Disc:** (expressed in terms of computer memory, such as MB or K or G). *How much space do I need on my disc in order to save this image?* When a digital image is saved to disc, its data is compressed. A computer index of image files will indicate the size of the packet of data on disc that is occupied by each image. This packet of data is **not** the same as pixel dimensions. Image data is compacted differently depending on many variables and might be subjected to either high or low compression ratios, thereby producing either larger or smaller files on disc. **Important: you cannot determine pixel dimensions by looking at a disc index of file sizes.**

**2. Compression formats:** jpg vs tif vs psd and others. See Understanding File Formats (below). Pixel images are known as bitmaps. The standard notion of format is actually more correctly called a *compression ratio*.

**3. Bit Depth:** generally, either 8-bit or 16-bit. Yielding a potential of either 256 or 65,536 levels of brightness per channel. Photoshop handles either 8- or 16- bit images (nearly) equally well. Many desktop scanners can acquire images in 14- or 16-bit. Before working on an image you must know your bit depth. Note: a 16-bit image will appear twice as large as an 8-bit image when measured as file size on disc, but *pixel dimensions* are not affected by bit depth.



**4. Color Space & Color Profile:** You might imagine a color space as a family of colors and color profiles as nametags identifying individual members of that family. Examples of color spaces include RGB, CMYK and Grayscale (B&W). Examples of color profiles include Adobe RGB(1998), ColorMatchRGB, and sRGB IEC69166-2.1 (which is the default color profile used in consumer grade digital cameras as well as on the world wide web). Color spaces, aka color models, are theoretical descriptive systems for identifying colors. Color profiles are digital tags that specify the exact dimensions of a particular color space.

**5. Resolution:** The word “resolution” can mean different things. For example, I sometimes hear the word “resolution” used to describe both pixel dimensions and display resolution.\* This can be confusing because these ideas are not equivalent. Keep in mind that a digital image is merely a packet of data—an abstraction of pixels (pixel dimensions)—that cannot be visualized until the pixels have been displayed in a grid. In order to do this, a *display resolution* must be applied to the grid. Until a display resolution has been determined, the picture isn’t a picture—literally, it has no size or shape.

*Display Resolution is fundamental to how a picture is displayed, but it is incidental to Pixel Dimensions.*

Note: In the computer, display resolution is expressed as *pixels per inch*. When printing, the *ppi* must be converted to *dpi—dots per inch*, the display resolution of the printer. While making a scan, or taking a picture with a digital camera, resolution is sometimes expressed as *samples per inch*—in the case of scanners and cameras, we’re not displaying but rather *capturing* pixels. A *capture resolution* produces the pixel dimensions of the digital image.

\**Display resolution*, as I’m using it here, is not a commonly used term in the basic literature of digital imaging. I use the term to differentiate between the “bones” of the picture, pixel dimensions, and the arbitrary decisions made when printing, or outputting, a picture visually.



## UNDERSTANDING FILE FORMATS

A picture displayed on a computer is a grid of pixels (as discussed above). Since each individual pixel is individually accessible, we talk about the grid as a map—a pixel map. In fact, the generic term for a picture made of pixels is “bitmap” (note: some computer pictures *do not* contain pixels, such as flat color graphics or text images, and are known as vector images). Confusingly, and unfortunately, Adobe Photoshop uses the word “bitmap” in a non-generic way to mean a specific type of black & white picture. (Keep the idea of a map in mind but don’t be misled by Photoshop’s use of the word *bitmap* to mean something quite different.)

In any case, *on closing a digital image and saving it to disc*—that is, folding up the map in order to put it away—you must choose a compression format that fits your needs. There are a wide variety of compression formats. You might recognize some—such as jpg and tiff and psd—and there are many others you might not have heard of, such as targa, pcx, or png. Your choice of



compression format can affect the quality of your picture when it is displayed or printed. For example, you might choose to fold up the map carefully and very neatly so that when it is unfolded later there are no wrinkles; or, alternatively, in order to fit the map into a tight small pocket, you might choose a folding method that is less neat and which may leave visible creases or wrinkles.

The more you work with digital imaging the more familiar you’ll become with the variables that affect your choice of compression format. The important thing to remember at the beginning is that, once a picture is open and editable in Photoshop, it is a pixel map, aka, a bitmap. No matter which compression ratio was previously used to close the picture (that is, no matter whether the filename on disc carries the suffix .jpg, .tif, .psd, or any other suffix), once it is open and ready to edit, it is a pixel map measuring a certain number of pixels high by a certain number of pixels wide.

Different compression ratios, or file formats, have different strengths and weaknesses. Some of the most common formats are:

**Photoshop (.psd):** the native Adobe image format. Identical on Mac and PC, but non-Adobe image applications might not be able to read it. **Pro:** Very high fidelity to original data, i.e., lossless. **Con:** large file size on disc.

**TIF (.tif):** a universal image format. Very widely used. Most image applications will read the TIF format. PC users must save images in IBM byte order. Macs will read TIFs in either IBM or MAC byte order. **Pro:** Very high fidelity to original data, i.e., lossless. **Con:** a) large file size on disc, and b) cannot save layers efficiently.

**JPG (.jpg):** a very common file transfer format, not usually an image editing format. That is, jpps are used mostly for transferring small files between web users, for example via web pages, or via email. Do not use the jpg format on pictures you are planning to edit. Macs and PCs read jpps in the same way. Depending on the compression ratio you choose in the jpg-save dialogue box, data can be compressed quite significantly, which reduces file size on disc but at the cost of also reducing image quality. Known as a lossy format. **Pro:** significant reduction in file size on disc. **Con:** substantial loss of image quality when saved at the highest compression ratio.

Rule of thumb: use TIF format for initial RAW conversions and original scans. Work-in-progress files should be saved in PSD format, with layers intact. Final output files should be flattened, sized and sharpened correctly, and re-saved as TIF or JPG files with unique, specific file names.