

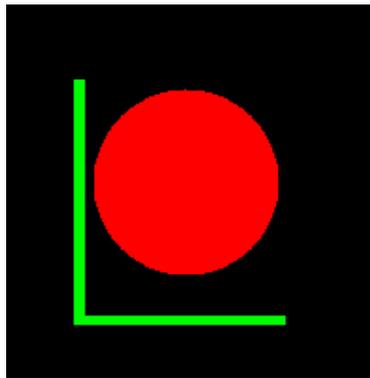
On bits and bytes

All data that is stored on a computer or any digital equipment is stored in bits. A bit stands for 'Binary Digit'. It is the smallest unit of information a computer uses. A bit is either a one or zero. By it self a bit can doesn't allow much information, but a computer works with an awful lot of bits and can therefore store a lot of information. Bits are usually grouped by the eight. This is called a Byte ('By Eight').

Since every bit can have two possible values, a byte can have $2*2*2*2*2*2*2*2$ (or in short 2^8) possible values: 256 in total. If you were to write a text document, each character is stored in a single byte. For instance capital letter A would be stored as '1000010' and its lower case equivalent as '10000110'. If you open the text document, the operating system on your computers retrieves all bits from disk, groups them into bytes and then converts each byte to a character.

On bitmaps (BMP)

In text documents, all bits are converted to readable characters. With images they are converted to tiny dots on your screen or paper, each with a distinctive color. These dots are more commonly known as 'Pixels', which is an acronym for 'Picture Element'. I produced the following drawing with Windows Paint:



Both height and width are 200 pixels. When saving this image, all the operating system does is writing the color of each pixel to disk. Paint allows 24 bit of colors, giving a total of 16.777.216 possible colors for each pixel. That is over 16 million!

This 'painting' therefore consists of $200 * 200 * 24 = 960.000$ bits, or 120.000 bytes of information. (Actually, the operating systems attaches just a few extra bytes of information, since it has to know that all these bytes represent an image, and not for instance a text document. So after selecting this file on your computer, you are presented with an image and not with a lot of odd characters).

Saving an image like paint does is known as a bitmap. The map has size 200 by 200, and each element contains 24 bits of information.

On compression

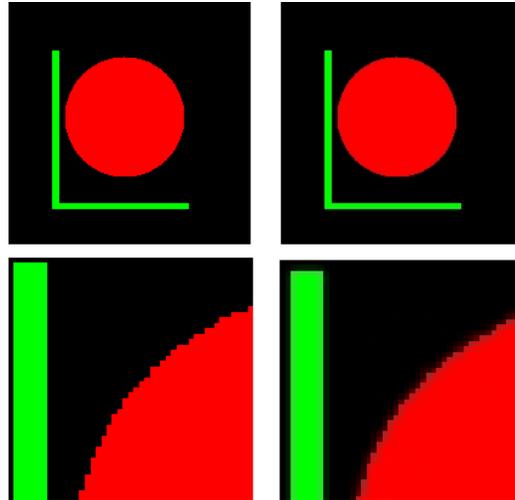
Whether you draw a simple square of 200*200 pixels, or store a photo like below, using the bitmap method, both images have the same size on disk.



This is not very efficient! The square has the minimum amount of detail and yet on disk it has the same amount of bytes as this photo. Now this is where compression kicks in. Instead of describing pixel by pixel, one might describe an image in terms of regions of similarity. The first image above can be described as a black square of 200 pixels in both height and width, with a red circular area of radius of 50 pixels, in the middle of the square. And two green rectangles of certain width, height and position. Describing an image in terms of this can dramatically decrease the numbers of bytes required, without losing any information. Obviously, the operating system needs to know what compression algorithm is used. It is appended to the file, known as the file header. And furthermore each algorithm is associated with a particular file extension, the same as '.bmp' stand for bitmap algorithm.

On JPEG (JPG)

Obviously, the image of the black and white cat is much more complicated to describe. Therefore intelligent algorithms were designed to cope with photographic images. One such algorithm is JPEG. It also describes the image in terms of similarity, but does a bit more. It doesn't store the image exactly, but leaves out less important information, like small color changes that can hardly be seen by the human eye. The JPEG algorithm decreases the size written to disk, at the cost of leaving out some information. Consider the initial drawing. Below, the drawing is compared to the JPEG one (to the right). A particular region is zoomed in at to see the difference:



The JPEG one seems a bit more smudgy. Besides it now uses 211 distinct colors instead of the three originally. However, zooming out again clearly shows that both pictures resemble quite a lot. The JPEG image uses about 7.000 bytes on disk, whereas the bitmap needed seventeen times as much disk space!

JPEG stands for Joint Photographic Experts Group (www.jpeg.org). It has widely been accepted as the standard for compressing highly detailed or "photo realistic" images, and is typically applied to digitized photographs. It incorporates a lot of mathematical algorithms, as said before, trying to leave out as much information possible that the eye can't appreciate. Designed for photographic images, it is no wonder that the compression of the simple drawing above yields a poor result. Should you want to reduce the disk size of images with text and sharp line drawings (like scans of text documents and clip art), one should rather use other standards like GIF and PNG.

On RAW

Unlike JPEG, BMP and most other file formats, RAW is no abbreviation or acronym, it is just what it says it is: raw, unprocessed image data. Each digital camera can have its own definition of raw data and you'll therefore rarely see a RAW image on the internet. Only after processing the data with vendor specific software, the data can be transformed to any suitable image format (usually JPEG). Consider RAW to be similar to the negative film.

Before describing in detail what RAW actually looks like, you should be familiar with the inside of a digital camera first. So more on RAW later on in our Learning Center.