Resolution Explained

Much confusion sometimes surrounds the question of just what resolution means in digital photography. Pixels, Pixels per Inch (PPI), Dots per Inch (DPI), dot density, screen size, print size and many other terms need a basic understanding to allow us to get the right combination for the task at hand.

Pixel

Pixel is a word coined by the photographic industry to describe the smallest element we can have in a digital photograph. Hence it is a picture element or pixel for short. A pixel is a single picture element and is the smallest element into which a photograph can be divided. A pixel can be only one colour, so a photograph is made up of a grid of thousands of pixels, each of varying colours that together make up the image. If you magnify a photograph enough, using an editing program, you will be able to see the individual pixels.

PPI can be described as the pixel density of the image or the number of pixels in a unit of dimension.

Resolution

Resolution, in simple terms, is the total number of pixels available. You will most probably already have come across the term megapixel that is used because a pixel is actually very small and so generates large numbers. Technically a megapixel is equal to 1,048,576 pixels. In reality however, camera manufacturers round this number to 1,000,000 when stating the maximum resolution the camera will capture. This information does not specify the actual pixel dimensions of the image, only the total number of pixels in the image. The actual pixel dimensions of the image depends on the configuration of the camera's sensor in terms of width and height or aspect ratio. A full frame DSLR has an aspect ratio of 3:2. That is it is three units wide and two units high.

For example, a 14.6 megapixel camera would have a full size raw image of 4672 pixels wide by 3104 pixels high (3:2 ratio). By multiplying these numbers 4672 x 3104 we get a total of 14,501,888 pixels, which is the actual number of pixels in the image. The camera manufacturer typically rounds this up to 14.6 megapixels.

Your camera manual will give you the actual numbers for your camera.

Picture Size

The actual physical picture size depends on the resolution, total number of pixels, the aspect ratio and the pixels per inch set in the image. For a screen display the PPI is generally 72, although some very expensive screens can display 96 PPI. This is the maximum number of pixels that can be displayed for each inch of screen width and height. For printing, the PPI generally needs to be between 250 and 300 PPI.

Screen Display

The density of pixels on the screen is 72 PPI. So, for example, a typical high density monitor that can display 1920 by 1080 pixels would, at 72 PPI, provide an image that is 26.6 inches (1920 divided by 72) wide by 15 inches (1080 divided by 72) high, which would fill a 30 inch (diagonal) screen.

Print Sizing

The number of pixels required for printing a photograph that displays good detail depends on the final size required for the print.

For example, if you want to print an image 6 x 4 inches (150 x 100 mm) at 300 PPI, you would need an image file that has 6 x 300 (1800) pixels on the long side and 4 x 300 (1200) pixels along its short side. This equates to a total of 2,160,000 pixels or 2.16 megapixels.

To print the same image as an 8 x 10 inches (200 x 250 mm) photograph at 300 PPI you would need and image file that has 8 x 300 (2,400) pixels along the short side and 10 x 300 (3,000) pixels along the long side. This equates to a total of 7,200,000 pixels or 7.2 megapixels.

Using the same mathematics as above the image file size for an A4 photograph would need to be (3507 x 2480 pixels) 8.7 megabytes and for an A3 print the size would need to be (4960 x 3507 pixels) 17.4 megapixels.

The term dots per inch (DPI) relates to the actual printer and printing process and is generally not a consideration when sizing your photograph for print output. The printer will calculate the number of actual ink dots from the PPI setting and the number of ink dots it can produce for each inch of the photograph dimensions, width and height.

File Size

The original size of the file produced by your camera depends on the file format used to record the image and the number of pixels your camera can record. A photograph captured in jpg format will be far smaller than the same photograph captured in raw format. This is because the camera processes and compresses a jpg file.

The basic size of a raw image is approximately the number of pixels in width times the number of pixels in height which is generally the resolution or maximum number of megapixels of the camera. The actual file size in bytes will be considerably more depending on other factors such as bit depth, compression and additional information added to the file by the camera.

For each pixel in an image the file needs to store at least three bytes (each 8 bits) of information to represent the value (a number between 0 and 255) for each of the colour components (red, green and blue) of the pixel . Some high end cameras actually use 12 or 14 bits for each colour to give a larger number of colours and shades. Hence, without compression or conversion, the file size in megabytes will always be much larger than the number of megapixels.

For example, the table below gives some typical file sizes for a 16.6 megapixel camera.

Image Quality	**File Size Mb**
RAW 12 bit lossless compressed	15.4
RAW 14 bit lossless compressed	19.4
RAW 12 bit uncompressed	26.5
RAW 14 bit uncompressed	34.3
Jpg Fine large	7.9

Image Size

The size of the photograph image output file is dependent on the pixel dimensions, that is the number of pixels wide times the number of pixels high. The pixel density PPI does not affect the file size if the pixel dimensions are kept the same. This can be shown by examining the file dimensions in Photoshop. In the first screenshot below the PPI is set to 72 with the image size set to 4032 x 2851. This gives a Photoshop file size with full colour information of 65.8 Mb.

In the second screen shot the pixel density is set to 300 PPI while keeping the image size at 4032 x 2851. The Photoshop file size remains at 65.8 Mb.

The difference is the physical size of the image produced. At 72 PPI the image would be 56 inches x 39.6 inches while at 300 PPI the image size would be 13.4 inches x 9.5 inches.

It needs to be noted that the file size shown (65.8 Mb) is the Photoshop image output file in bytes that contains Photoshop processing information and does not directly relate to pixel dimensions of 4032 x 2851 or 13.1 megapixels. Also worth noting is that when saved to disk in psd format the file is 339 Mb,

again reflecting all of the Photoshop processing information including multiple layers. When flattened and saved it reduces to 67.4 Mb on the disk.

The same file saved as a jpg is much smaller at 4.95 Mb but is still independent of the pixel density, PPI.