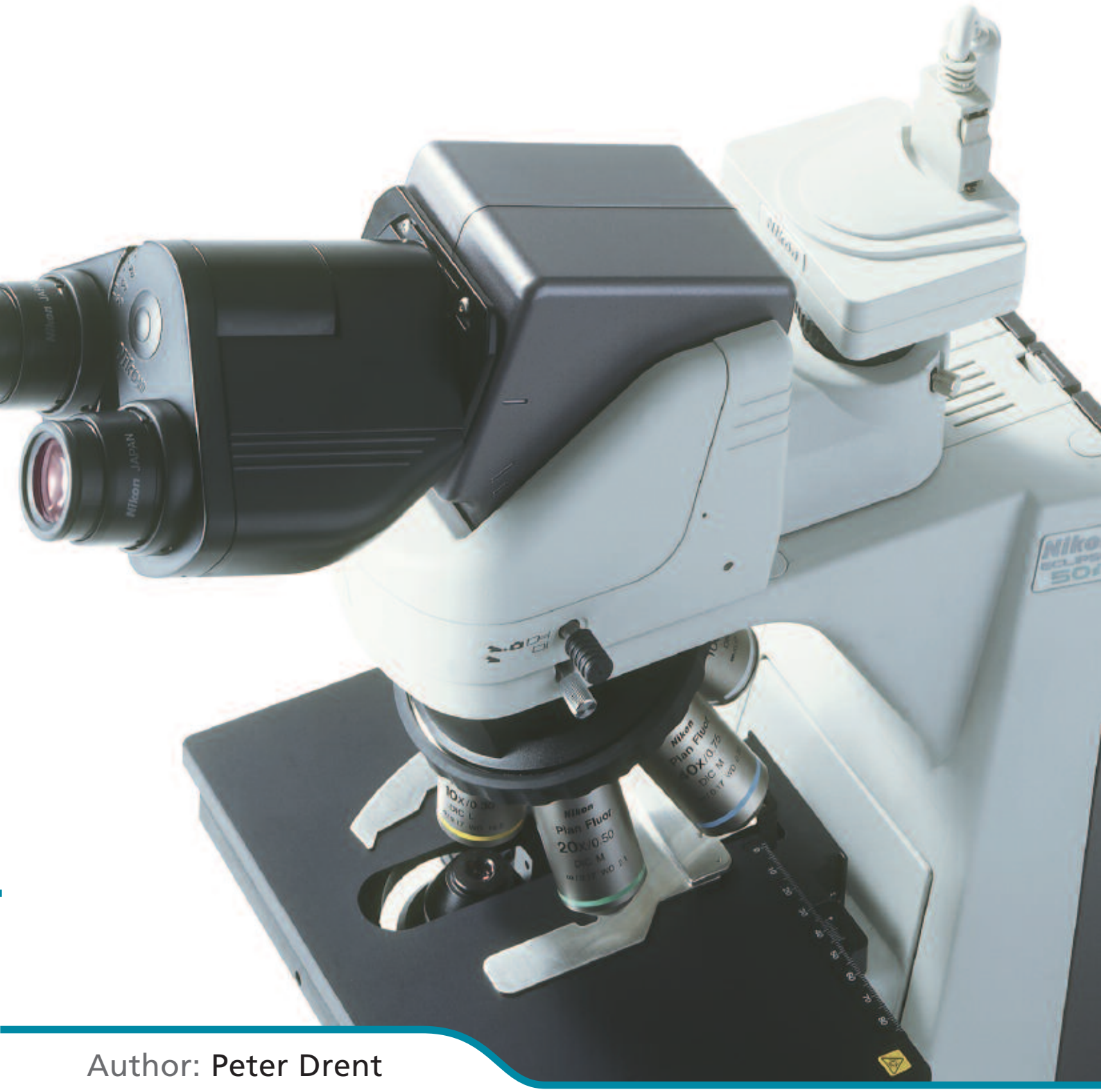

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Making the choice between a 5-mega pixel and 2-mega pixel camera head

Abstract:

A number of camera heads are available for Nikon's Digital Sight cameras based on either 5-mega-pixel (5M) or 2-mega-pixel (2M) capabilities. The end use of the image is a key factor in deciding whether or not a high resolution, high pixel number camera is required. For many applications image capture resolution greater than 2-mega-pixel may not be necessary and especially when using high magnification, high N.A. lenses. High pixel acquisition creates large image files. Compression may be required to aid file management. Compression will not affect image quality as long as the image size is also proportionally decreased. Capturing at 2-mega-pixel resolution does not require compression and enables printing at all popular sizes. A monochrome camera has a higher capture resolution than a colour camera.

Introduction:

When digital cameras first came onto the market, there was a tendency to select cameras purely on the basis of pixel number. This was thought to be the key limiting criterion for capturing and storing high resolution images. With today's digital cameras pixel number alone is rarely a limiting factor in camera selection. In this technical note, the significance of pixel number, pixel size, lens quality, colour/monochrome capabilities and file size and compression are discussed with particular reference to Nikon's Digital Sight series of cameras.

Technology:

Nikon's Digital Sight series of digital cameras is based around two controllers (DS-U2 & DS-L2) and a number of camera heads that can be connected to either controller. The choice of controller is often straightforward, for example, for stand-alone operation the DS-L2 is required and for fast PC connection, the DS-U2 is required. The selection of the correct camera head can sometimes be more difficult. There are five available camera heads in two series; 5M and 2M available in both colour and monochrome:

1. DS-Fi1 colour camera
2. DS-5Mc colour camera, Peltier cooled version, room temperature – 20°C
3. DS-2Mv colour camera
4. DS-2MBW monochrome camera
5. DS-2MBWc monochrome camera, Peltier cooled version, room temperature –20°C

Table 1: Specifications of the 5M and 2M camera heads

	5M	2M
Model name	Sony ICX282AQ	Sony ICX274AL
CCD type	Interline CCD image sensor	interline CCD image sensor
Image size	Diagonal 11mm (Type 2/3)	Diagonal 8.923mm (Type 1/1.8)
Number of pixels	2658 (H) 1970 (V) approx. 5.24	1688 (H) 1248 (V) approx. 2.11M pixels
Chip size	9.74mm (H) 7.96mm (V)	8.50mm (H) 6.80mm (V)
Pixel size	3.4µm (H) 3.4µm (V)	4.40µm (H) 4.40µm (V)

Specifications of the 5M and 2M cameras are compared in table 1. The 5M cameras have a greater number of pixels than the 2M cameras (2658 compared with 1688). While pixel number is considered by many to be the key determinant for image quality, other parameters are also important. Figure 1, for example, shows the relationship between pixel number, numerical aperture and the magnification of the objective lens.

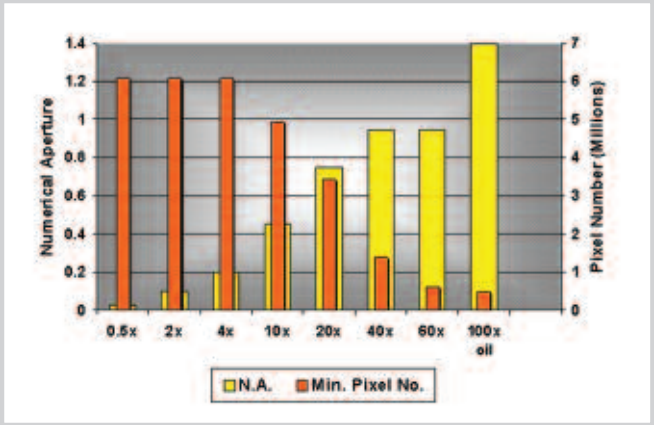

Fig 1: Graph: The relationship between pixel number, numerical aperture and magnification

High magnification, high numerical aperture (N.A.) lenses require fewer pixels compared to lower magnification, lower numerical aperture lenses. The field of view is also much smaller in high magnification, high N.A lenses. The relation between digital sampling and optical resolution should follow the Nyquist criterion: sampling frequency should be 2 -3 times the source frequency.

When working with magnifications greater that 20x, the 2M pixel camera head is adequate for quality imaging. Use of the DS-Fi1 camera head may be unnecessary when using high magnification, high N.A. lenses. This not only results in unnecessary large image files but also slows image transfer from camera to computer.

Image transfer and storage of large files can be made more manageable through compression. This does not affect image quality as long as the image size is also proportionally decreased. Microsoft Office Picture Manager (Windows XP), for example, offers four levels of compression: (1) Don't compress, (2) document, (3) web pages, and (4) e-mail. As these compression settings are used, the resulting images become smaller in size to maintain picture quality (see Figure 2). If images are re-sized to a uniform size, there is very little visible difference in image quality in the first three cases (Figure 3). However, if an area of the image is enlarged difference can be seen between no compression (1) and the documentation image (2) (Figure 4).

In almost all cases, a 2-mega-pixel camera captures the full resolution of the objective lenses. Capturing at 2-mega-pixel resolution does not require compression and enables printing at all popular sizes. The benefit of the 2-mega-pixel camera is the speed of operation; faster updates of live images and faster image transfer speeds to the computer Pixel size is the most striking difference between the chips used in the 5M and 2M camera heads (3.4µm versus 4.40µm respectively). This equals to about 40% difference is photon-collecting area, resulting in 40% more sensitivity for the larger pixel.

Fig 2: Image compression and image size. To maintain image quality, images decrease in size. Images are taken with Nikon D70. From left to right:

No compression: 2000x3008 ~ 6 M pixels, resulting in a 2.36MB file

Document: 681x1024 ~ 0.7 M pixels, resulting in a 106 KB file

Web pages: 298x448 ~ 150K pixels, resulting in a 27.9 KB file

E-mail: 106x160 ~17K pixels, resulting in a 5.99 KB file

Fig 3: The effect of resizing compressed images on image quality. The "documentation" image (2) was taken as the starting point. The size of the "no compression" image (1) was decreased and the "web page" image (3) and "e-mail" image (4) were increased in size.

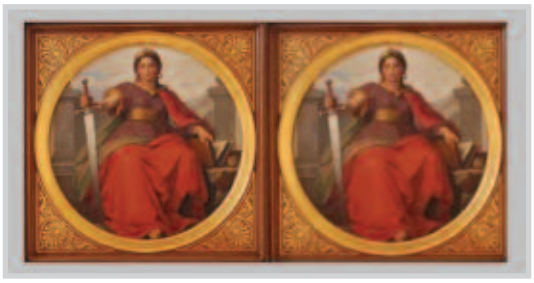

Fig 4: Left: no compression. Right: documentation image.

The DS-Fi1 camera replaced the DS-5M camera head. Both models use the same chip but differ in read-out electronics. The DS-Fi1 uses a new read out algorithm that increases image resolution by 15%. The DS-Fi1 uses a new IR cut filter with a slightly longer cut off wavelength than the DS-5M resulting in better red colours. The DS-Fi1 has a faster readout then the DS-5M, especially when combined with the new DS-U2 controller (table 3):

Table 2: U1+5M and U2+5Fi1: Comparison of read-out rates

	U1+5M (frames/s)	U2+5Fi1 (frames/s)
VGA Central	14	22
VGA Normal	7	12
SXGA	4	7

As well as differing in the number of pixels, the different DS camera heads area also available in colour and monochrome versions. In a colour camera the pixels are covered by a Bayer Mosiac filter, which is an arrangement of blue, green and red filters. The most popular filter arrangement is blue, green, green, and red. Of four pixels, this means that one receives blue information, two receive green and one receives red information (Figure 5). Each pixel, therefore, receives only a part of the spectrum. This is in contrast to a monochrome camera, where each pixel receives the full spectrum. A monochrome camera, therefore, has a higher capture resolution than a colour camera.

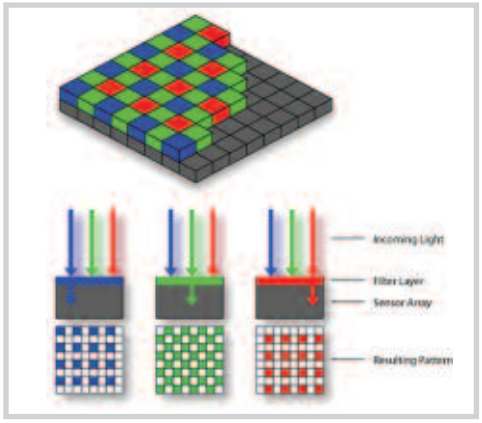

Fig 5: The Bayer Mosaic filter and image capture in a colour camera.

Application:

When selecting a camera for any imaging application, it is important to consider the end use of the images as this may affect the selection of a higher versus a lower pixel camera.

Many digital images are intended only for use on a computer screen display. At most, these screens currently operate with UXGA (1600 x 1200) resolution. Image capture at a resolution greater than 2-mega-pixel may not be necessary. Even when images are destined for print, an A4 print at 300DPI requires only 9MP. In most cases print requirements are for images much smaller than A4. In addition, printing at 150 DPI produces acceptable results. A guide to the number of pixels required for 72, 150 and 300 DPI for an A4 print are provided in table 2, together with various sizes of monitor display.

Table 3: Pixel requirements for A4 print and various sizes of monitor display.

A4 page print	
72 pixels / inch	822 x 616 = ~ 500K pixels
150 pixels / inch	1713 x 1284 = ~ 2.2M pixels
300 pixels / inch	3425 x 2569 ~ 8.8M pixels
Monitor display	
1024 x 768	~ 800K Pixels (XGA
1280 x 1024	~1.3M Pixels (SXGA)
1600 x 1200	~ 1.9M Pixels (UXGA)
2560 x 2048	~ 5M pixels (QSXGA)

Conclusion:

The choice of digital camera depends on the end use of the images. Contrary to the belief of many digital camera users, high pixel, high resolution cameras may not always be required. Even when printing images, in most cases a 2-mega pixel camera will suffice. Resolution is not simply dependent on the number of pixels, but also depends on the pixel size, lens quality and whether or not colour filters are used on the chip.

Authors Background

Peter Drent is a microscopy General manager - Bioscienncе at Nikon Instruments, Europe BV. He has a special interest in digital imaging technologies and is a frequent speaker at Nikon's Digital Imaging Seminars. Mr Drent has a degree in biology from the University of Utrecht in the Netherlands.

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References:

http://www.microscopyu.com/articles/optics/opticshome.htm

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The Nikon Instruments organisation has established a number of Nikon Imaging Centres to make available the latest microscope developments to the researchers and to create an interaction between research and the Nikon product development. Nikon Imaging centres have been established in:

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- 5M Camera ideal for for lower magnifications, NA and fps
- 2M camera for ideal for higher magnification, NA, and fps
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