pcwexpert

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PHOTOGRAPH PATRICK LLEWELYN-DAVIES

scanners

Welcome to the first pcwexpert. Each month we're dedicating 16 pages to an in-depth look at one subject.

This month Gordon Laing delves into the world of scanners, their origins, how they work and how you can get the best out of them. Read on to find out more and become a PCW expert on scanners.

From a swinging pendulum to electrical signals

When a French physicist couldn't find a use for his discovery, a Scot developed the idea and set the scanner ball rolling

A scanner is a device that captures something for later use. In the context of this feature, the subjects under capture are images, whether photographic prints, transparencies, documents, or real-life 3D objects. From this point on, unless otherwise stated, we'll use the term scanner to refer to image capture only.

The basic principle of a scanner is similar to that of a facsimile system, except that the scanner integrates the transmitter and receiver into one unit, whereas the facsimile transmitter and receiver may be on opposite sides of the planet.

The first scanners captured and processed originals, while reproducing them onto film almost simultaneously. For modern desktop scanners, the processor is the PC and the final receiver is usually a printer, or some kind of electronic media.

Where it all began

Arguably the father of scanners was Scottish physicist and clock maker Alexander Bain (1818-1903). In 1843 Bain proposed a facsimile telegraph transmission system based on discoveries made by French physicist Edmond Becquerel a few years earlier. Becquerel discovered that when two pieces of metal were immersed in an electrolyte, an electrical charge was developed when one of the pieces was illuminated. He couldn't think of a practical use for his discovery.

Bain, however, proposed that this could allow metallic characters to be chemically transmitted. Later, his transmitting machine used a detector mounted on the end of a swinging pendulum to sweep over the subject and scan it line by line. As the detector passed over areas of ink, it emitted a different electrical signal to when it passed over areas of no ink. This signal contained the original image, broken into small portions for transmission. The signals were transmitted over a telegraph wire to the receiving device, which applied them to chemically treated paper, recreating the image.

The problem of synchronising the two devices was solved by using large metronomes set off at the same time. The Italian Giovanni Caselli constructed an enormous version of Bain's facsimile machine called the Pantelagraph in 1856. Four years later, Caselli used this to transmit the first long-distance fax between Paris and Amiens – an impressive 70-mile distance, but one that required the use of eight-feet tall pendulums.

First scanner

Modern fax machines and scanners are based on photo-sensitive elements, and the first practical transmission using photo-electric cells was developed by German physicist Arthur Korn in 1902. By 1925, the American Telephone and Telegraph company (AT&T) had invented the first wire photo service.

In 1929, Bavarian electronic engineer Dr Rudolf Hell formed a company in his own name and applied to patent a 'device for the electronic transmission of written characters' – he called this electronic fax machine the Hell Recorder.

The first prototype drum scanner was constructed from a modified engineering lathe by Alexander Murray and Richard Morse in 1937 – at the time, Murray was working for Eastman Kodak. In 1946, Time took the Kodak prototype and continued its development until, in 1949, the Austin Company built it into the first workable scanner, known as the Austin Scanner.

In 1947 John F Crosfield founded Crosfield Electronics. In 1955 he invented the first colour scanner, the Scanatron MK1, which used a cathode-ray tube and flying spot, similar to the technology behind TV sets; the first model was installed at Sun Printers in Watford in 1959. Crosfield's subsequent inventions included the first commercial drum scanner in 1964.

Returning to the early 1950s, Hell entered the world of reproduction with his invention of the Klischograph, which could convert continuous tone and line images directly into Klishees, or printing blocks. In 1950 Hell introduced the Colorgraph, an experimental flatbed scanner. Many innovations followed, but one of the biggest landmarks was the 1970 launch of the Hell DC 300, an enlarging and reducing scanner using digital technology.

Crosfield beat Hell to the first enlarging and reducing drum scanner (MagnaScan 450) a year earlier. Until now, scanners had captured and reproduced images the same size as the original. In 1975 Crosfield released the MagnaScan 550 drum scanner

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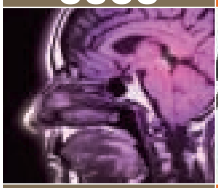


The date and origin are arguable, but no-one can dispute that the benchmark image capture and processing system is the human eye and brain. The best scanner in the world!

1843

Fax machine invented by Alexander Bain, who proposes a facsimile telegraph transmission system, built in 1856 using eight-feet pendulums and called the Pantelagraph (above).

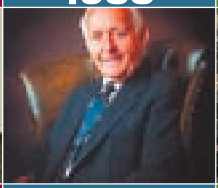
1929

Dr Rudolf Hell invents graphic transmission concept used by almost all fax machines today. Hell later merged with Linotype and both were recently swallowed up by Heidelberg.

1950

The first experimental flatbed scanner, the Hell Colorgraph, invented by Dr Hell (above). In 1970, Hell launched the DC 300, the first digital enlarging and reducing drum scanner.

1955



First colour scanner, the Crosfield Scanatron MK1, invented by John F Crosfield, using cathode-ray tube and flying spot. Crosfield invented first drum scanner in 1964.

1969

Charge Coupled Device (CCD) invented by George Smith and Willard Boyle at Bell Labs. Stores electrical charge proportional to the amount of light that falls on it.

that, for the first time, exposed four colour separations simultaneously under the control of an integrated digital computer.

Drum scanners are still used in professional reprographic environments. They enjoy a higher tonal dynamic range and suffer from less noise than Charge Coupled Device (CCD)-based scanners.

The image is mounted on a spinning transparent cylinder – the drum. A high-pressure Xenon lamp illuminates the subject and the reflected or transmitted light is detected by Photo Multiplier Tubes (PMTs). Four PMTs are used: three with red, green and blue filters, and the fourth for an Unsharp mask channel. In the early days the electrical signal from the PMTs could be adjusted to control brightness and colour correction in real time, before driving a lamp to expose photographic film for colour separations. Now, the signal is converted into digital data and manipulated by a PC, before being used to output colour film separations.

The silicon revolution

A silicon chip sits at the heart of almost every modern imaging device. Invented in 1969 by George Smith and Willard Boyle at Bell Labs, the light-sensitive CCD revolutionised digital imaging.

Microtek claims it was the first to produce a 300dpi (dots per inch) CCD-based sheet-fed black and white scanner in 1986. Agfa produced the first scanner for the Mac market in 1987. Microtek was also first with a 300dpi 24bit colour flatbed in 1989. However, until the early 1990s, flatbed scanners were still expensive. Users on a budget who wanted to capture images had to rely on a short-lived breed of handheld scanners. Resembling small car vacuum cleaners, these had a 4in wide scanning window, and the user dragged the unit over the image. AMS was first with a handheld scanner in 1988, but was soon after bought by Swiss mouse-giant Logitech. The latter dominated the handheld market, which peaked with the £399 ScanMan Colour in 1992.

In the mid to late 1990s, the dedicated document scanner made a comeback. Previously an attachment for a flatbed device, this new breed was little larger than a half-finished roll of kitchen paper and fed papers through with rubber rollers. Visioneer was the undisputed king of these document scanners.

However, many unknown Taiwanese companies were building scanners for the big boys, but toward the end of the 1990s they realised they could competitively market themselves. Within a couple of years, the average price of a flatbed scanner plummeted. Flatbed prices seem to have bottomed out today, but have just about eliminated every other type of budget scanner. The CCD is also gradually approaching the quality of high-end drum scanners, with innovative 'XY-Stitch' flatbeds moving their CCD heads both vertically and horizontally over the image to produce extremely high-resolution scans.

It is, however, refreshing to remember that the best quality imaging device is also the oldest. Coupled with the advanced processing, recognition and storage features of the human brain, our very own eyes are the best scanners in the world.

Scanners explained

Flatbed **Pros** - Flexibility of scanning photos, film, documents, card, books, small objects; **Cons** - Occupies lots of desk space and you shouldn't put anything on the lid

Drum **Pros** - Highest quality scans make drums the choice for high-end reproduction; **Cons** - Very expensive, large and require expertise to operate

Handheld **Pros** - Smallest desktop scanner, and cheap too; **Cons** - Small scanning area, average quality, increasingly rare

Document **Pros** - Small and dedicated to document scanning, management and OCR (optical character recognition); **Cons** - Not suitable for thicker originals, typically poor colour quality, also rare

Network **Pros** - High-speed document scanning and server support - ideal for large offices; **Cons** - Large, expensive and not on your desk. Requires network expertise

Film **Pros** - Concentrates high optical resolution into small area to capture small frames; **Cons** - Low flexibility - only scan film, and some only do 35mm

Digital camera **Pros** - Portable, captures small and large objects, pretty flexible; **Cons** - Quality only sufficiently good for A4 prints with 3.3megapixel models

1973

The barcode standard, a linear design used to label and identify products, is chosen as the Universal Product Code symbology. Checkouts are never the same again.

1981

Heinrich Rohrer and Gerd Karl Binning invent the Scanning Tunnelling Microscope, a scanner that can image tiny atomic details. Scary insect photos follow.

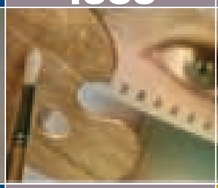
1988

AMS launches first handheld scanner, and soon after is bought by Logitech. In 1992 Logitech releases ScanMan Colour for £399. Handhelds are almost extinct today.

1989

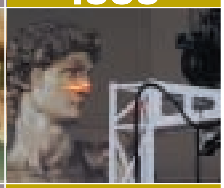
Microtek launches the world's first affordable 300dpi three-pass 24bit colour flatbed. By the mid-1990s, the Taiwanese dominate the budget flatbed market.

1989



Adobe Photoshop is launched and becomes the killer application that revolutionised digital photo retouching and sold millions of scanners in the process.

1999



Stanford and University of Washington complete project to scan the sculptures and architecture of Michelangelo in 3D using custom laser rangefinder and gantry.

The power behind digital imaging devices

We take an in-depth tour around the technology that makes a scanner work and explain how you can get the best results

All digital imaging devices work on the same principle of reflection or transmission. The subject is placed before the imaging device, consisting of a light source, optics and a sensor. The amount of light reflected by or transmitted through the subject is gathered by the optics and focused onto the sensor, then converted to a voltage proportional to the light intensity – the brighter the image, the more light is reflected or transmitted, resulting in a higher voltage. This voltage is changed by an analog-to-digital converter into bits of information the computer can understand.

The subject

In practice the range of subjects we want to capture digitally is varied, so many different imaging devices have been developed. Flatbed scanners are currently the most widespread, although digital cameras are increasing in popularity. While scanners and cameras seem, on the surface, to be very different, their purpose is the same: to capture a subject and present a computer with a bitmapped digital image file.

In the case of the camera, you simply point it at your subject and expose the entire sensor in one go, using natural or man-made light sources. The scanner, on the other hand, operates in an almost clinical environment, encompassing the subject and using its own light source for consistent illumination.

While a camera is forced to expose its entire sensor in one go to capture fast-moving subjects, scanners operate at a quite leisurely pace. Whether in a drum, on a flatbed, or dragged past by hand or rubber rollers, the scanner slowly passes its sensor over the subject (or vice versa) in a capture process that typically takes between 10 seconds and two minutes depending on the technology. For more detail see the *History* section of this *pcwexpert*.

The sensor

The most common sensor in digital imaging is the Charge Coupled Device (CCD), which is at the heart of most scanners, digital still cameras and camcorders. A CCD consists of many tiny photo-sensitive elements arranged in a rectangular grid in the case of a video or digital camera, or in a long, thin line in desktop scanners; the more photo-sensitive elements per unit length, the higher its resolution, and greater its capability of resolving fine details in the subject. The CCD in a scanner may be 2-3in long, while one in a digital camera may only measure 0.5in across its diagonal. The number of genuine photo-sensitive elements in a CCD used to capture the subject is its optical resolution.

The energy associated with the photons of light that strike a photo-sensitive element during an exposure are absorbed by the silicon and converted into electrical charge. At the end of the exposure, the amount of charge in the element is directly proportional to the number of photons that struck it, and to the relative brightness of the subject at that point. By converting the charge from a load of photo-sensitive elements placed closely together, it's possible to capture and recreate the subject. It's like placing transparent graph paper over the subject and measuring the brightness in every square, the smaller the squares the more accurate the reproduction will be.

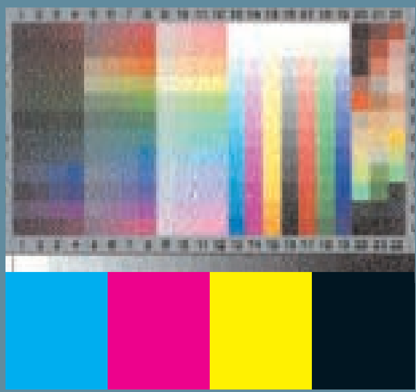
Colour correction

Ever had one of those conversations where you're describing something as rusty orange coloured, but are then stopped and told it's clearly pillarbox red, or worse still, lime green? Yes, we all have very different ideas about colour and computers are no different.

The trouble is that monitors and scanners work with red, green and blue (RGB) light in an additive process, whereas printers work in a subtractive process using cyan, magenta, yellow and black (CMYK) inks. Not only do you have to convert between colour spaces when printing a scan, but the CMYK model cannot reproduce the same range of colours as RGB.

Just because your monitor and scanner both work with RGB doesn't mean they won't give you colour headaches. Your scanner has no idea what the brightness, contrast, or colour temperature settings of your monitor are. It's crucial to ensure your monitor is correctly set up before you start making tonal and colour adjustments on scanned images. TFT monitors are not capable of displaying the same levels of detail in shadows and highlights as a CRT.

The solution is to employ a Colour Management System (CMS) that will calibrate each component so what you scan should look the same on screen and the printed page - or at least close enough to work confidently. These systems will also warn you if you're trying to reproduce a colour that's clearly out of the printer's capabilities.



Fortunately, the International Colour Consortium (ICC) has gone to the trouble of developing a standard to describe the colour characteristics of any device, be it a scanner, monitor or printer. Called ICC profiles, they effectively plug into colour management software that can make the required corrections and compensations. ICC profiles are available for many popular imaging devices, but you can make your own by measuring how your device handles standard test targets packed with tricky coloured squares. Many decent printer drivers can be fed an ICC profile for a scanner and the printer itself, in order to produce calibrated output. If you fancy a quick, easy, yet effective means of colour matching, check out Colorific, available to order online for around £35, or bundled with some monitors and graphics cards.

Colorific: www.ecolor.com

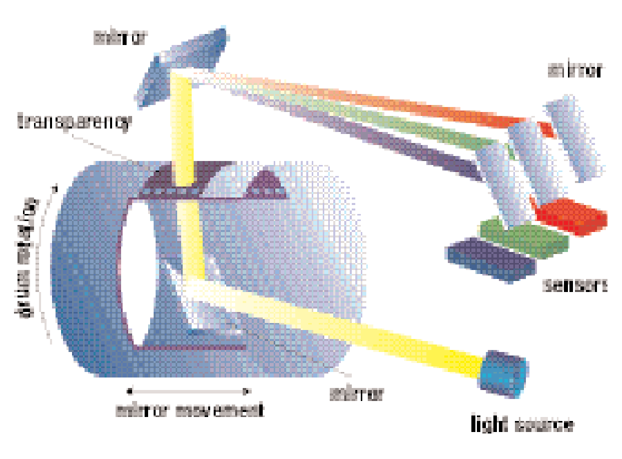
Modern budget scanners are increasingly using an array of illuminating LEDs and contact image sensors instead of a fluorescent tube and CCD for capturing images. Unlike flatbed CCD arrays that measure only a couple of inches across and use a lens to capture the full A4 width, an LED system evenly spreads its elements across the entire 8in document width. This allows them to produce images that are as sharp at the edges as they are in the middle and not rely on optical lens quality for edge performance as CCD units do.

Brightness alone doesn't, however, contain any colour information. To capture full colour, you need to place suitable filters in front of the CCD. Since mixing different amounts of red, green and blue light can make up the entire visual spectrum, digital imaging devices place red, green and blue filters in front of their CCDs – like a cathode-ray tube in reverse. Normally there are three separate CCDs, each with a different filter, while on older scanners a single CCD builds a full-colour image in three passes.

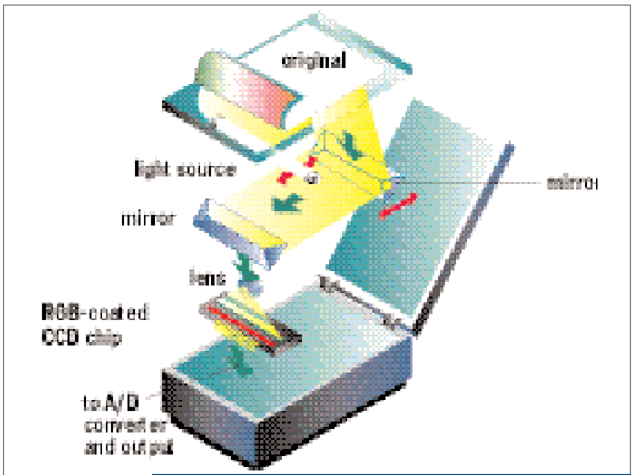
Pixels and resolutions

Once the exposure is complete, there will be three brightness values representing a tiny section of the subject: one each for red, green and blue. When combined, the result is a single full-coloured dot, often called a pixel. Since most digital imaging devices are used to capture colour subjects, their resolution is described in full colour. Cameras, webcams and camcorders are described by the number of effective colour pixels used to capture the whole subject in one go. Hence a camera with 1,600 x 1,200 colour pixels is described as having 2.1 million pixels (2.1megapixels).

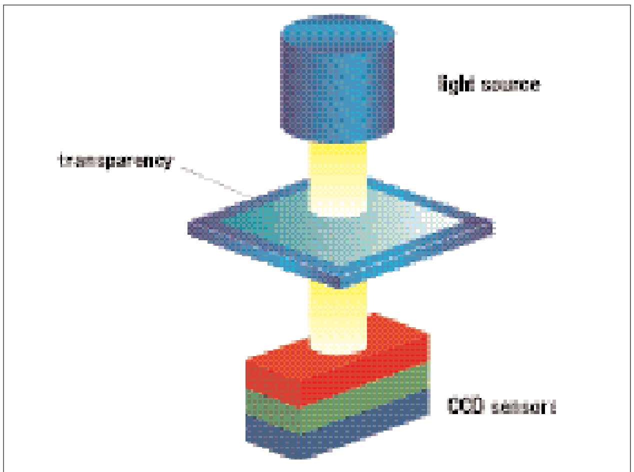
Since scanners capture subjects of different sizes, their resolving power is more fairly described as a number of dots or pixels per inch (dpi or ppi). The important figure is the optical resolution, since this refers to the number of effective photo-sensitive elements in the CCD, as opposed to extra dots invented by software later in the process.



Drum scanners: high quality but expensive



Flatbed scanners: flexible but take up space



Film scanner: can capture small frames

Unlike a camera's rectangular CCD with hundreds of dots horizontally and vertically, the CCDs used by most scanners consist of a single line of elements in a row. While the scanning CCD may only be a few inches long, it captures a much wider area using special lenses and mirrors.

A scanner claiming a horizontal *optical* resolution of 600dpi and a maximum capture width of 8in will have 8 x 600, that's 4,800 light-sensitive elements on its CCD. Most colour scanning heads contain a fluorescent tube light source with three such CCDs, filtered for red, green and blue light, plus optics to focus the subject onto the CCDs. These allow the scanner to capture a full-colour image in a single pass in around 30 seconds.

A scanner's vertical resolution is dictated by the degree of fineness by which the imaging head can be directed over the image. The first affordable PC scanners were built into handheld devices that the user dragged across the subject. Document scanners or fax machines use motor-driven rollers to drag the subject through the device and over the CCD. In the case of a flatbed scanner, the head is driven by a stepper motor, a device that turns a predefined amount every time it is fed an electrical pulse. The maximum vertical resolution may exceed the horizontal one thanks to the stepper motor being highly geared; an optical resolution of 600 x 1,200dpi is not unusual, but the important number is the (normally smaller) horizontal one referring to the actual CCD.

The optical resolution describes the maximum amount of genuine detail the device can capture. But if you look too closely, you'll see the steps originally used to chop up your subject during the digitising process. In the case of image capture, you'll begin to see the pixels as small solid squares of colour that get more obvious the greater you enlarge the picture. The closer you want to look at or enlarge a digital image, the more pixels you'll need to capture it with in the first place. This is why optical resolution is such a crucial specification of any digital imaging device. However, short of buying a higher-resolution device, what can be done to eliminate these jagged edges?

Interpolation

The apparent resolution of a digital image can be increased by interpolation, which under software or hardware control guesses intermediate values and inserts them between real ones.

In theory, if your image has a red pixel next to a yellow pixel, it may be fair to assume that if there were an additional one in between, it would be orange. Interpolation would add that orange pixel in the appropriate place, effectively doubling the apparent resolution of the image.

In practice, interpolation can be more sophisticated. To create just one new pixel, normally all its surrounding neighbours are considered, and in some cases, the interpolator looks further outwards in the attempt to predict a trend. Of course, if you've gone to all the trouble of creating one new pixel, why not go the whole hog and insert several more between your 'real' pixels. This is exactly what's offered by just about every scanner on the market, with some 600dpi optical devices boasting interpolated resolutions up to 9,600dpi. It doesn't take a trained eye to treat such figures with at least a little scepticism, and it's certainly true that most of the time they're used purely in a marketing numbers game. So is interpolation all bad?

In the negative camp, interpolation cannot invent detail that was never captured. Consider a car number plate, where the characters are just beyond the resolving power of the imaging device and haven't appeared on the final picture. While a higher-resolution optical device would capture the characters, no amount of interpolation on the lower-resolution image will make them appear.

On the positive side, interpolation will increase your number of pixels to a point where the jagged edges will be smoothed away. Sure, there won't be any additional detail in your picture, but at least you won't be plagued by a blocky image. Interpolation can really help when it comes to making an acceptable-looking big enlargement from a modest-resolution digital camera.

It's worth pointing out that some original subjects are very simple and can be successfully predicted. While the car number plate is a tough subject, consider a simple circle as part of lettering or a logo. When captured with low resolution, the stepped edges of the circle will be painfully apparent, but interpolation could be used very successfully to fill in the gaps with smaller dots, producing a considerably smoother result. As with so many aspects of digital imaging, the results depend on your particular subject, device, additional processing and personal expectations. Consequently, you may find interpolation to be a winner on one day, but a pointless loser on another.

You'd be forgiven for thinking that raw resolution is the be-all and end-all of digital imaging

Dynamic range

At this point you'd be forgiven for thinking that raw resolution is the be-all and end-all of digital imaging. While it is the single most important specification of an imaging device, one that follows very closely behind is dynamic range.

So far we've discussed brightness and colour as simple abstract values but, in the world of digital imaging, real numbers are required for everything. In the same way that optical resolution physically chops a subject into a grid of manageable pixels, so must each brightness value be assigned a number. The difference between the lightest and darkest value that can be captured is known as the dynamic range, and it's this range that's also divided up during the digitising process. Like optical resolution, the more steps that can be assigned to describe a level of brightness, the more accurate the result.

The assigning of a nearest number to describe a brightness value is the job of the analog-to-digital converter within the device. Normally these are described as operating with a certain number of bits. Just like graphics cards, 8bits give you 256 levels, 16bits offer 65,536 and 24bits boast just under 16.8 million levels. It's generally accepted that the human eye cannot distinguish between adjacent grey levels when 256

File formats

There is a wealth of graphics file formats to choose from, which can make a huge impact on the quality of your image and the amount of storage space it occupies on your PC. It's crucial to consider where you're going to use your image before making any file format decisions that could permanently compromise its quality.

Before the days of web dominance, the most common graphics file format was the Tagged Image File Format (TIFF), which stores the contents of a bitmap image in the required number of colours and nothing more. The only problem was that file sizes could become unmanageable - a 10 x 8in 300dpi TIFF in 24bit colour measures over 20MB.

As exchanging images became increasingly common online, CompuServe developed the Graphics Interchange Format (GIF). This format reduced the total colour palette to 8bit, then looked for identical coloured pixels in a row. By describing rows of identical pixels in one go, simple images could be highly compressed without any loss of quality. This technique is known as Lemple-Zif-Welch (LZW) compression and is used by WinZIP, as well as being offered as an option when saving TIFFs from some applications. LZW is not particularly efficient at compressing full-colour images, but since the process operates without any loss of quality, you may as well use it where available. Beware of saving photos as GIF files though, as in almost all cases it will permanently reduce your total colour depth to only 8bit.

Undisputed king of Internet image formats is the JPEG from the Joint Photographic Experts Group. Unlike LZW, JPEG employs so-called lossy compression, which permanently throws away information it deems unnecessary. The level of compression is set by the user, with higher compressed images occupying less space, but looking worse for it. Finding out how much compression is tolerable is a case of experimenting, and you'll find some images look better than others. Photoshop 5.5 offers an invaluable preview of how the compression will look compared to the original. While perfect for delivering full-colour images online, we recommend important pictures are archived in the TIFF format as backup. Although using the best-quality JPEG settings may not produce the smallest file in the world, but the resulting image will be almost indistinguishable from the original.

levels are used. So basic colour scanners employ 8bit analog-to-digital conversion for each of the three colour filters, red, green and blue, making a total of 24bits per full-colour pixel.

Unfortunately, a few of the least significant bits are lost in electronic noise, while any post-scanning tonal corrections reduce the range further still. It's for this reason that superior scanners boast not 24bits per pixel, but often 30 or 36bits, or sometimes more still. These offer a much higher dynamic range with finer steps between adjacent levels, resulting in greater tonal detail, particularly in dark shadows or bright highlights. Most applications, and especially printers, cannot handle this tonal range, but once your device has captured it, you can shift these subtle details into tonal ranges that can be finally reproduced. Capturing an increased dynamic range also gives you more room to breathe when making other tonal corrections, after which you should still have a great set of 24 most significant bits to output.

Sadly, dynamic range has also become a marketing numbers game of late, with many bargain-basement scanners described as offering 36bits per pixel. While it's remarkable what cheap scanners can deliver, don't kid yourself that their final tonal performance will be anywhere near that of a high-end scanner. Tonal performance separates the men from the boys in the digital imaging world, with those that talk the talk, but not walk the walk suffering from undesirable noise and lack of detail in shadows and highlights, regardless of the number on the box. Even as high-end CCDs improve, ultimate tonal dynamic range still requires the photo-multiplier tubes used in drum scanners.

Tonal density

Density is the degree of opacity of a photographic image on paper or film, and is usually described as a number between 0 and 4.0D. It's a description of tonal range, calculated as the Log10 of the number of grey levels – hence in theory, 8bit 256 grey level has 2.4D, 10bit 1024 grey level has 3.0D, while 12bit 4096 grey level achieves 3.6D. Scanners are often described as capturing a certain density, but marketeers of cheap products often quote theoretical figures, without taking noise and surface reflection into account. The highest density ranges are still in the realm of drum scanners which may genuinely deliver as much as 4.0D (approaching 16bit greyscale).

Getting the image out

At this point in the capture process, the subject has been exposed to and measured by the imaging sensor, and a massive amount of data generated. It's this data that's processed by the scanner's built-in firmware, often under user instruction via the software driver mentioned in a moment. In the meantime, the data has to be transferred from the imaging device into the PC for subsequent use.

In the past, the dominant interface for connecting all types of scanners to computers was SCSI, which still boasts high performance along with broad device connectivity options. SCSI was the most common scanner interface since it used to be a standard fitting on Apple Macs that previously dominated the digital imaging market and are still the most popular platform in many high-end facilities.

As PCs entered the digital imaging arena, SCSI cards were fitted to allow them to communicate with scanners. However, as many Taiwanese manufacturers moved into the market and drove scanner prices down at the entry level, a new cheaper interface was required. For a short period, the enhanced capabilities of the PC's ever-evolving parallel port were employed, but with variable

Configuration tips

Adobe Photoshop dominates the high-end photo retouching and image-manipulation market. Much of its success is down to licensing deals where Photoshop or a cut-down version is bundled with many scanners as standard. Buying a scanner is a great way of getting hold of a copy of Photoshop, as even the limited versions come with attractive upgrade offers. The current version is 5.5, which includes a copy of ImageReady 2.0, designed for getting images optimised for web use. Online graphics manipulation is an increasing business for Photoshop, which started life as the professional printer's best friend.

Manipulating images can be thirsty work for a PC, but there are ways you can lighten the load. What follows are some configuration tips applicable to all photo retouching applications, and a few just for Photoshop.

Ultimately, memory is key. The instant you run out of memory, your hard disk is enlisted to pretend, but it's absolutely nowhere near as fast. Consequently, if image manipulation is your thing, ensure you have sufficient memory to handle your common files entirely out of RAM, and remember your applications and operating systems will want a fair portion too. When it comes to printing images, a large amount of memory also comes in handy. We recommend at least 128MB to get started with digital imaging, with 256MB and above advised for serious work.

As far as Photoshop is concerned, Adobe recommends three to five times the amount of system RAM as the size of the image you're working on. If that isn't possible, remember to purge the cache from time to time - you'll lose your 'undos', but free up memory. Also, in Photoshop's preferences, devote all available RAM to Photoshop, and when working on heavy images, quit all other applications.

The speed of your hard disk is also paramount as it defines how long you have to wait to open and save images and prepare pictures for printing, along with being a big factor in virtual memory performance when you run out of RAM. Bigger and faster drives are always better, but consider using a pair of hard disks, as both drives firing simultaneously can effectively double your bandwidth. Try installing your OS and application on one disk, but keeping, say, files on the other.

Photoshop uses its own virtual memory system called a Scratch Disk. Decent performance increases can be enjoyed by devoting your second hard disk to the Scratch Disk. It's also useful to check the efficiency and scratch ratings in the corner of Photoshop to measure available system resources.

success usually depending on the age of the motherboard. Today the dominant interface at the low to mid-range is USB, allowing reasonably quick data transfer, but more importantly for most users, easy connectivity.

At the high end, SCSI still holds on to much of the market, although several devices now have IEEE-1394 FireWire interfaces. These mostly cater for modern Macs that have dumped SCSI in favour of FireWire, although, ironically, many high-end Mac users fit third-party SCSI cards to retain compatibility with older peripherals.

Never the TWAIN

We take many PC technologies and innovations for granted. One of the most useful, but often ignored, was the Windows printer driver, which installs just one driver for a particular printer, that can then be used to output from every Windows application. Sounds obvious, but in the old days, a different printer driver was required by each application. Believe it or not, a similar situation existed with scanners for much longer.

Until quite recently, a scanner was supplied with a standalone piece of software that was launched each time you wanted to scan. Once your image was scanned, you had to save the often large file before launching your image-editing application and laboriously opening the file again – hardly ideal.

The solution for Windows was developed by Hewlett-Packard, Kodak, Aldus (since merged with Adobe), Logitech and Caere. Called TWAIN, but not standing for anything, it's a single scanner driver available for control from any TWAIN-compliant application.

TWAIN-compliant applications usually have two options on their File menus to select between multiple imaging devices, then to acquire the image from the chosen device. During acquisition, the scanner's unique set of drivers and controls are presented, without having to leave the host application. Once scanning is complete, the driver window closes, leaving the scanned image open in the host application. No unnecessary quitting, launching, or saving of potentially large or useless files.

TWAIN can be used to control almost any imaging device and, while in the early days it was occasionally used for digital cameras, today it's almost exclusively used for scanners.

All TWAIN drivers have much in common. Dominating the proceedings is a preview window that presents a low-resolution picture of the subject. Once previewed, the TWAIN driver lets you crop the subject to capture the area you desire, along with adjusting brightness, contrast and, in more sophisticated drivers, the colour and tonal curves. Generally, the TWAIN driver will take the most significant 24bits that remain after correction and deliver these to the host application. However, since the TWAIN driver is talking directly to the scanner, this is the place to make tonal corrections, as here you're dealing with the maximum dynamic range of the device. Some scanner/TWAIN combinations can output more than 24bits to your PC, but you'll need a suitable application to deal with them. Photoshop's 48bit RGB mode can handle colour depths greater than 24bit, but almost all the options are greyed-out, and you'll be dealing with file sizes double that of 24bit.

Within the TWAIN driver you also set the operating resolution and optional interpolation. Next to these are normally the colour settings, for capturing different types of subjects. While full 24bit (or higher) colour is suitable for colour photographic work, black and white photos need only 8bit greyscale modes, and pages of text for OCR work may only require basic mono 'line-art' capture – note that some OCR packages can make use of greyscale information for better recognising text. A CMYK option may also be available for delivering an image optimised for a specific printer, normally using standard ICC colour profiles (see Colour correction box). Epson's scanner drivers have optional settings optimised for its range of Stylus Photo printers.

What resolution?

The biggest question facing all scanner users is deciding which resolution to use. Popular misconceptions include using the highest available simply because you've paid for it, or matching the scanner's dpi with that of your printer. The real answer is to consider the size of your subject and the size and environment in which you'd like it reproduced. For starters, we'll consider colour inkjet printers.

First, forget the resolution of your printer, as this normally refers to drops of ink and not the number of full-colour scanner pixels that can be reproduced. Virtually every colour inkjet printer is happy being fed around 200 full-colour dots of information per printed inch. Lesser models may be happy with 150, while top-of-the-range ones may be able to make use of up to 300, but any additional information will be ignored and just slow down the image handling process.

Consequently if you have a 6 x 4in photo that you want reproducing same size on your inkjet printer, scan it at 200dpi. If you want it reproducing half the actual size, then halve the resolution to 100dpi. If you want it double the size, then double the resolution to 400dpi.

High resolutions are only required when significantly enlarging small subjects. Photographic film is a prime example, where a 35mm frame measures only 1in tall. Scan this at 200dpi and you'd only get a 1in tall print. To enlarge it to 4in tall, you'd need to scan at 800dpi. To make a 10 x 8in print, you'd need to scan at 1,600dpi. While you can fit a transparency adaptor to a flatbed scanner that shines light through the film, the sad fact is that most flatbeds just don't have sufficient optical resolution to handle 35mm film. Instead, you should use a dedicated film scanner. Typical models may only handle 35mm subjects, but boast optical resolutions of 2,700dpi, sufficient to produce a good-looking A3 print.

Scanning for the web is the other way around. The target viewing device is a monitor, which, depending on the display mode, will be operating between 70 and 100dpi, with each on-screen pixel directly handling one colour scanner pixel. So for a display running at 70dpi, scan at 70dpi for same-size reproduction, 35dpi for half-size, 140dpi for double-size and so on.

See the workshops later for some more advice on scanning for print, the web and film.

Scanning terminology

Scanner technology is full of acronyms and specialist words, but the pcwexpert Glossary reveals all

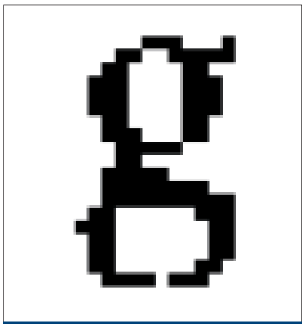
Artefacts: Undesirable elements on an image introduced through limitations of a digital device, processing or compression system. Typically they show up as snow-like noise, speckles, blocks or banding.
CCD: Charge Coupled Device. A type of silicon chip used in many imaging devices. Uses a grid of light-sensitive elements that store electrical charge proportional to the amount of light falling on them. The charge is converted into digital data for processing.
CMYK: Cyan, Magenta, Yellow and Black. The four colours used by almost every printing process. By printing these four inks in different sized dots, the eye is fooled into perceiving full colour. CMYK is often offered as a scanning mode that is optimised for a specific printer. (The letter K is used for Black to distinguish it from the B for Blue in RGB.)
CMS: Colour Management System. Ensures colours you scan are the same that you see on-screen and on the printed page. Limitations in various devices mean some colours can never be perfectly matched, but a CMS can help prevent nasty surprises.
Compression: Mathematical formulas used to identify redundant information in a digital file and remove it to save storage space or transmission time. Compression can either operate in a lossless form where there is no loss of quality, or lossy which reduces quality, but can significantly decrease file sizes.
Density: Degree of opacity in an image, usually between 0 and 4.0D. A description of tonal range, it's often quoted as a scanner specification, but there is a difference between theoretical density and the tonal range a device can deliver.
Drum scanner: Lathe-like device that mounts image on a transparent spinning cylinder. Large, expensive, requires trained operators, but offer best quality.
DPI: Dots per inch, often used to describe the resolution of a scanner or printer. Since a printer needs to drop lots of dots to recreate one full-colour scanner dot, many scanners now describe their resolution in the more accurate pixels per inch (PPI).
Dynamic range: The range of measurable tones in an image, ie the difference between the lightest and darkest portions.
Flatbed: A scanner in which the original is placed on a glass plate under a lid. Resembling a slim photocopier, flatbeds are the most flexible scanners available.

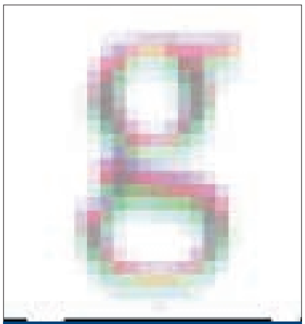
ILLUSTRATION TOM GREEN

GIF: Graphics Interchange Format. Graphics format developed by CompuServe for online use. Reduces colour depth to 8bit (so not as suitable as JPEG for photographs) then uses LZW lossless compression.
Halftone: Technique used to reproduce a continuous-tone photograph as a mosaic of tiny dots. Halftoning gives the perception of full colour, when in fact only four different inks are typically used – see CMYK.
Histogram: A graph that indicates the tonal distribution of an image and the relative number of times each tone is present. Typically presented from 0 (black) to 255 (white), with shades of grey between. Histograms are very useful for evaluating the quality of a digital image and tonally correcting it.
Interpolation: Mathematical process of increasing apparent image resolution by averaging adjacent pixels and inserting new ones. It will never create new detail but can smooth edges.
JPEG: Joint Photographic Experts Group. Most common image file format used by digital cameras and on the web. Uses permanently lossy compression, but at a user-variable level.
Line art: Black and white, monochrome mode offered by some scanners to capture text.
Lossy: Type of digital compression that permanently throws away information in an attempt to reduce file sizes. Used by JPEG format – see above.
LZW: Lemple-Zif-Welch. Lossless compression used in WinZIP format, and several graphics formats such as TIFF and GIF.
Moiré: Undesirable patterns produced as a result of scanning an image that has already appeared in a book or magazine, ie halftoned. De-screening options on some scanners can reduce the effect.
Newton's Rings: Undesirable artefact that can occur when light shines though glass in the scanning process. Flatbeds sometimes suffer, where dedicated film scanners may not.
OCR: Optical Character Recognition. Software that attempts to recognise shapes as characters from a scanned document, and output the result as an editable text file. It is rarely 100 per cent accurate but will save time retyping documents.
Optical: As in optical resolution, the genuine resolving capabilities of a scanner. Many unscrupulous marketeers prefer to highlight the 'invented' interpolated figures.
PMT: Photo Multiplier Tubes. Sensors used in drum scanners, which boast much higher tonal dynamic ranges than CCDs.
PPI: Pixels per inch. Used to describe resolution of scanners – see also DPI.
RGB: Red, Green and Blue. The three lights used by displays or filters used by scanners to handle the full visible spectrum of colour.
TIFF: Tagged Image File Format. A popular uncompressed graphics file format. Sometimes offers 'LZW' option.
Transparency Adaptor: Replacement lid for flatbed scanners. Contains own light source to shine through transparent originals onto the imaging CCD. A driver lets you convert negatives to positives, but relatively low optical resolutions mean small enlargements from tiny 35mm frames.
TWAIN: PC standard for scanner drivers. Activated using the Acquire option on an imaging application's File menu, the TWAIN driver presents all the scanner's capture options. Doesn't actually stand for anything. Macintosh scanner drivers are normally supplied as Adobe Photoshop plug-ins.
Unsharp mask: A traditional film compositing technique used to sharpen image edges. Now offered digitally by many apps, it can correct blurring introduced during photographing, scanning, resampling or printing.

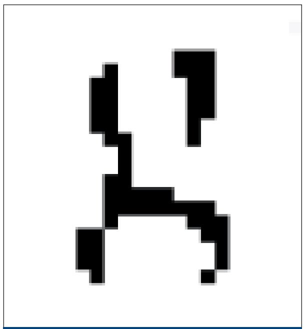
Unravelling the numbers game

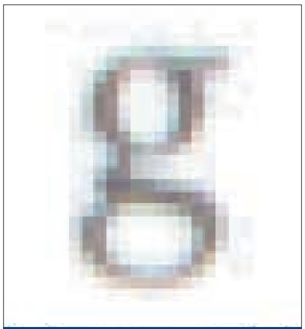
The numbers quoted by scanner manufacturers often bear no relation to the actual resolution or tonal dynamic range

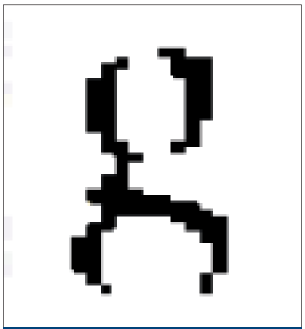

Scanner 1 - 300dpi optical

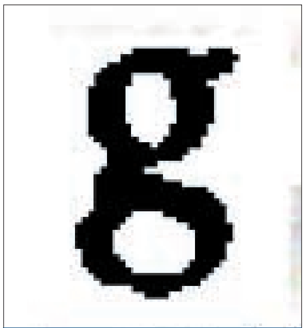

Scanner 1 - 300dpi RGB optical


Scanner 1 - 2,400dpi interpolated


Scanner 2 - 600dpi optical

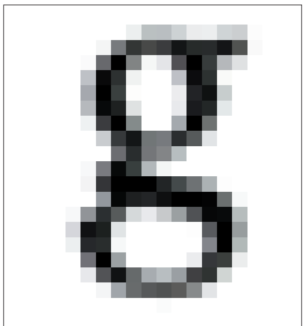

Scanner 2 - 600dpi RGB optical

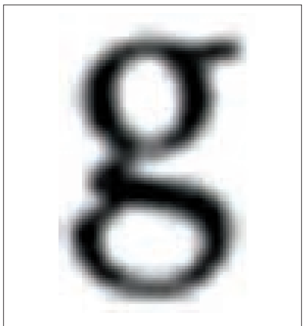

Scanner 2 - 9,600dpi interpolated


Scanner 3 - 300dpi optical


Scanner 3 - 300dpi RGB optical


Scanner 3 - 9,600dpi interpolated


Digital camera 200dpi A4 optical


Digital camera 1,000dpi interpolated


Digital camera 2,500dpi macro optical

The most important scanner specifications are genuine resolution and tonal dynamic range, both of which have been described in detail earlier. Sadly, scanner marketing has a severe case of number-itus, where bigger is always perceived as better. In truth, the figures quoted are frequently misleading and in many cases bear no relation to the actual results. We devised two tests in order to find out how truthful various specification claims are in reality. On the left are the results of our resolving power and interpolation tests, while the histograms on the right reveal true tonal capabilities. In each of the two tests we took different sets of budget flatbeds to illustrate our points.

Resolving power

The images on the left show the results of our resolution test for three different budget flatbeds and one digital camera; we'll discuss the flatbeds first. We took an A4 page of text and scanned it at the highest optical resolution in both mono and colour modes – this was typically at either 300 or 600dpi (dots per inch). Then we scanned the same page at the highest interpolated resolution, which claimed to be from 2,400dpi to as much as 9,600dpi in some cases. As we discovered, the numbers are often meaningless.

Each scan was cropped to reveal a single character: a letter g measuring a mere six points, or 1mm tall. From left to right is the optical resolution in mono, optical in colour and interpolated in mono.

Taking the three mono optical results in the first vertical column, our third budget scanner delivered the best result, even though it was rated at 300dpi. Note the worst result from scanner two, despite claiming 600dpi optical resolution.

The colour results are interesting if only to illustrate the convergent problems facing a budget flatbed. Each of these letters in the middle vertical column should be pure black with the minimum of colour fringes. Again, scanner three delivers the best result, but none of them can really be described as great.

Interpolation

The interpolated results are particularly revealing. Remember, each of the three results down the far right-hand vertical column were generated by the scanner from the results down the first vertical column. Given this as a starting block, scanners one and three have produced remarkable results, but note the claimed resolutions of each model. Scanner one has the best interpolated result, but only describes it as 2,400dpi, compared to scanners two and three claiming 9,600dpi. While scanner three's result is good, clearly the 9,600dpi result of scanner two leaves much to be desired.

Digital camera

At the bottom are some results from the Nikon CoolPIX 990 3.3megapixel digital camera. We photographed the same A4 page of text in uncompressed TIFF mode to avoid JPEG artefacts. With 2,048 pixels for the entire height of the page, the camera was effectively working at around 200dpi, and the result on the far left is understandably blocky. The middle image shows the result after we took it into Adobe Photoshop and interpolated it up to 1,000dpi. It has significantly smoothed the edges. Out of interest we set the Nikon to macro and got as close as we could to the page (right-hand image), capturing just over one inch across, it was effectively working at around 2,500dpi, and the result is, of course, very smooth. With modest-sized text, digital cameras of 3.3megapixel resolution can now clearly be used for OCR work. Compared to the flatbeds, the Nikon's colour convergence is very good too – remember each of the three test images was taken and reproduced in colour.

Tonal range

To measure and compare tonal and colour capabilities, we scanned a standard IT-8 test target, pictured at the bottom of this page, using three different budget flatbeds (not the same models as in the resolving test). The IT-8 consists of a grid of colours and a strip with 21 distinct greyscales.

Using Adobe Photoshop's histogram tool we analysed the coloured and greyscale sections separately. The top graph represents the range of colours captured, which should ideally slope off smoothly at the extreme ends. Where it falls short at the left or right sides, shadow or highlight details respectively are being lost. The lower graph should ideally show 21 sharp, thin and evenly spaced peaks; the reality indicates the number of greyscales resolved and the inability to separate adjacent grey levels in some cases.

Consider the upper graphs of figures 1, 2 and 3 for the colour results first. All three scanners are failing to capture any detail in the darkest areas using automatic settings. Figure 1 is clipping at the bright right-hand end rather than falling smoothly off as the scanner in figure 3 is doing. The one in figure 2 is simply not capturing any detail in either the dark or bright areas using automatic settings.

In contrast, the scanner in figure 2 has the best defined peaks in the lower greyscale graphs. All three models are having difficulty separating the darkest greyscales from each other, but the scanners in figures 1 and 3 are also blurring the distinctions between adjacent grey levels.

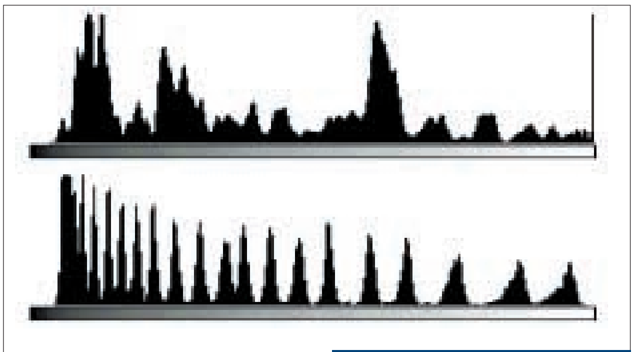


Figure 1

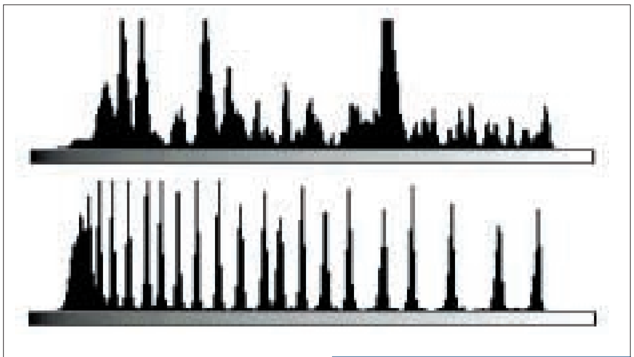


Figure 2

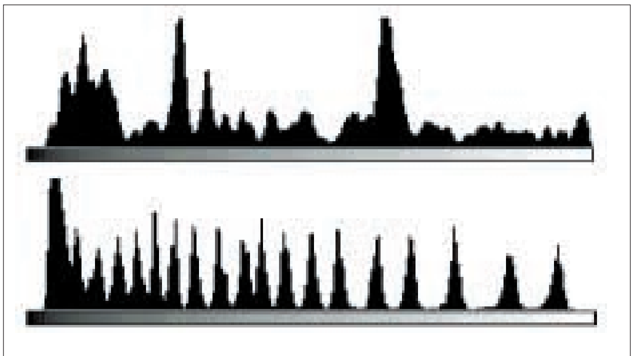
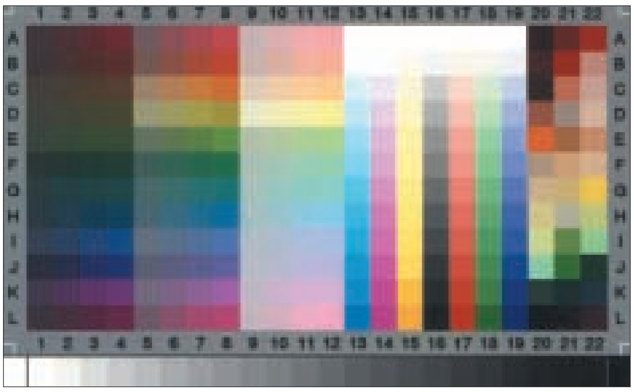


Figure 3



Moving towards another dimension

Technology is moving so fast that it won't be long before we will be able to touch and feel 3D digital objects

What does the future hold for image acquisition? In terms of capturing two-dimensional objects, there's not a great deal left to achieve. Since the late 1990s, the Taiwanese have forced down the price of entry-level flatbed scanners to a point that has reduced many established companies to tears. Certainly, higher optical resolutions and improved tonal density will become ever more affordable, but the physical side of the flatbed scanner is unlikely to change all that much. Companies like Canon have done a great job in recent years of slimming down their flatbeds to sylph-like proportions, but most still have at least an A4 footprint and don't like anything resting on their lids.

While flatbeds offer high flexibility and decent quality at low prices, other technologies are fast catching up. A digital camera is essentially a portable scanner that doesn't need a permanent connection to your PC – many can capture moving video too. When you consider that all digital cameras feature built-in power and storage facilities, capture their images in split seconds and are pocket sized, you've got to ask why you're using a flatbed.

The answer is that the controlled environment of a flatbed offers better capturing of flat originals, such as documents and photographs. As time goes on, though, the resolution of digital cameras will increase to a point where they'll match flatbeds, while cunning post-processing will ensure that 2D flat-capture is a snap. Proper document management and OCR facilities can't be far away on digital cameras.

Times are slowly changing at the high end of image capture. The PMT technology of drum scanners may still claim the top-dog position, but how much longer can these dinosaurs fend off steadily maturing CCD-based solutions? Flatbeds may seem large in the desktop world, but compared to floor-standing drum scanners, they're tiny and highly desirable in cramped reprographic environments.

Resolution on CCD scanners is no longer an issue, with switchable lenses concentrating resources onto specific areas, and new high-end XY-Stitch flatbeds moving their imaging heads both vertically and horizontally across the image. You can bet that the tonal dynamic range will also improve in the near future and PMTs will shuffle off into retirement. Particularly innovative designs from companies like Imacon (www.imacon.dk) are changing the way high-end professionals think of CCD scanners.

Software won't be standing still either. As image files increase in quality, they'll inevitably need more of your precious storage space.

In the world of consumer audio and video, the days of uncompressed digital formats are now just about over. DVD didn't get where it is today by not compressing its data and forthcoming high-end audio standards are also likely to use plenty of the squeezing stuff.

The JPEG file format can preserve image quality in a reduced space, but programmers and developers the world over are working on more effective means of compression that offer better quality yet ever smaller storage requirements. As devices sport faster processors, the intensive compressing and decompressing stages will be significantly reduced, allowing new formats to infiltrate the mainstream.

The real breakthroughs, however, will be in the realm of 3D scanning and we're not talking about using a digital camera to make a 2D image of a 3D object. Instead we mean capturing three-dimensional co-ordinates of an object, then being able to move around it or zoom in and out. With improvements in human interfaces, we'll be able to pick up and feel purely digital, non-existent objects.

Far-fetched? Not really. 3D scanning has been with us for many years in fields as diverse as movie special effects and the automotive industry. Both have real-life objects they wish to capture in every detail (be it an actor's head or a car), for later testing and processing.

In the same way that a digitally captured image can be emailed across the world and printed out, a 3D scan can be transported electronically, and manipulated on screen or reproduced in three dimensions. Stereo-lithography uses a laser to draw thin sections of a model, one sliver at a time, in liquid plastic. The plastic hardens and the shape is recreated.

The trouble with 3D scanners today is that they are large, bulky, fixed devices. This is necessary in order to precisely place the scanning head in relation to the object and collect accurate co-ordinates. Far better would be a handheld portable 3D scanner, which could capture an object in a process not dissimilar to filming it with a camcorder.

While simple for the operator, the compensation and reconstruction algorithms would be horrifically complicated. For a handheld 3D scanner to work, the processing would have to be carried out in real time and, while that isn't commercially possible for small-scale users today, the never-ending increases in processor performance should make such devices a reality in the future. Pie in the sky? No way – Canon has already demonstrated such a unit at its research centre in the UK, and *PCW* featured a similar device from 3D Scanners on p25 of the June 2000 issue.

One thing is certain: image acquisition devices are getting smaller, more portable and offering ever better quality. One wonders what Alexander Bain, inventor of the fax machine, would say to a handheld 3D scanner... he'd probably ask where the pendulums were.

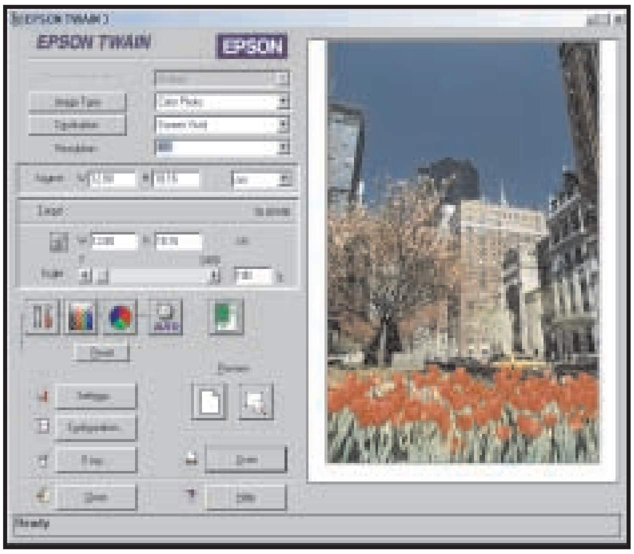
3D scanner in action mapping a Merc A Class

PHOTOGRAPH 3D SCANNERS (UK)

We'll be able to pick up and feel purely digital, non-existent objects

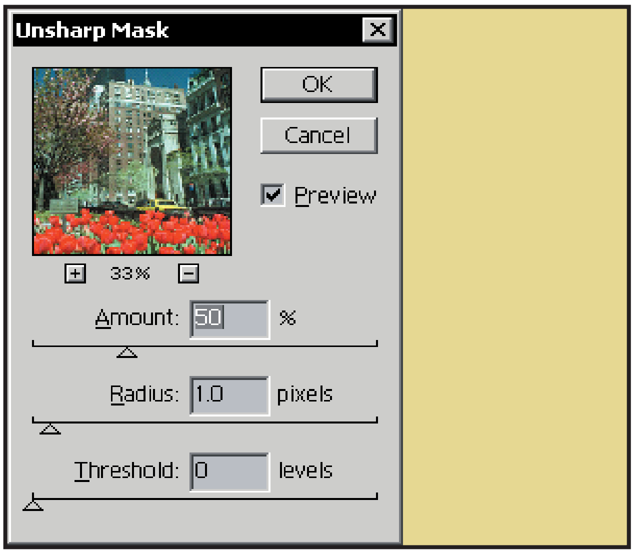
Scanning for printing

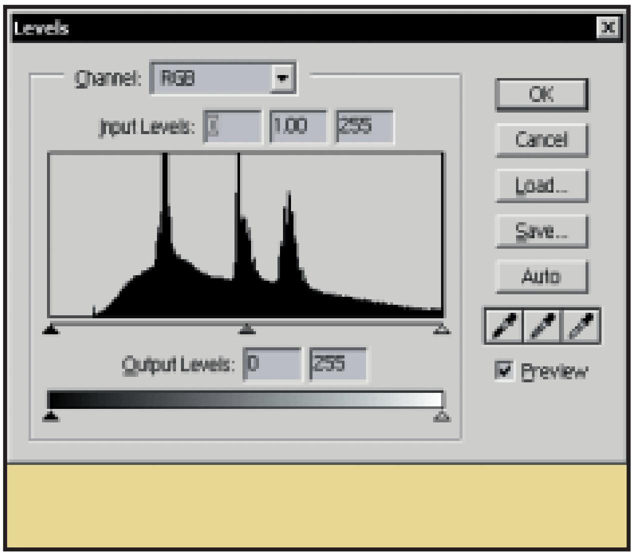
If you want to create a colour printout of a holiday snap, our first workshop shows you how to get the best results



1 The trick with scanning is to know the limits of your output device. Most colour inkjets are happy to be fed between 150 and 300 full-colour scanner pixels per printed inch. Try out different settings to see if you can tell the difference, but we find that around 200dpi is sufficient for most photos. Here we've set the scanner TWAIN driver to scan at 200dpi, and have made a preview of our photo. We've selected the picture and zoomed in – it's a 5 x 7in photo, hence the driver is stating a source of 12.80 x 18.16cm. The file size in 24bit will be 4.12MB.

2 If you want to resize the picture, then you'll need to change the resolution. It's a simple equation: double the size means double the resolution, whereas half the size means half the resolution. Since we've discovered that 200dpi is sufficient for same-size reproduction, then a double-size enlargement will require scanning at 400dpi, and a half-size reduction will require only 100dpi. Note that in the above screenshot at 400dpi, that the target file size has increased from 4.12MB to 16.49MB, reflecting the increase in image data.

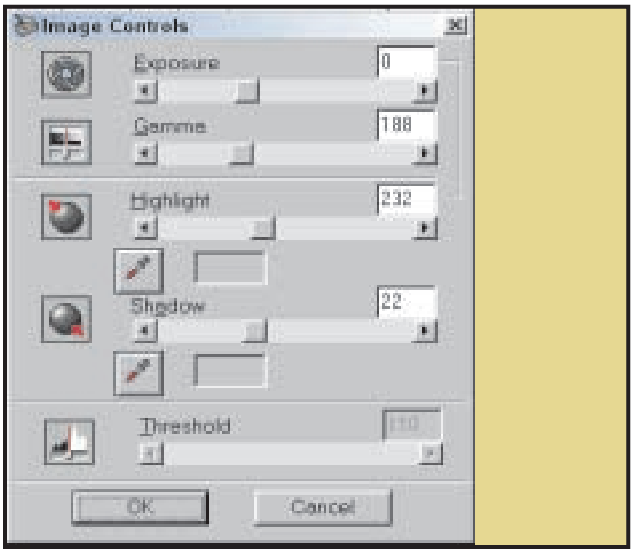




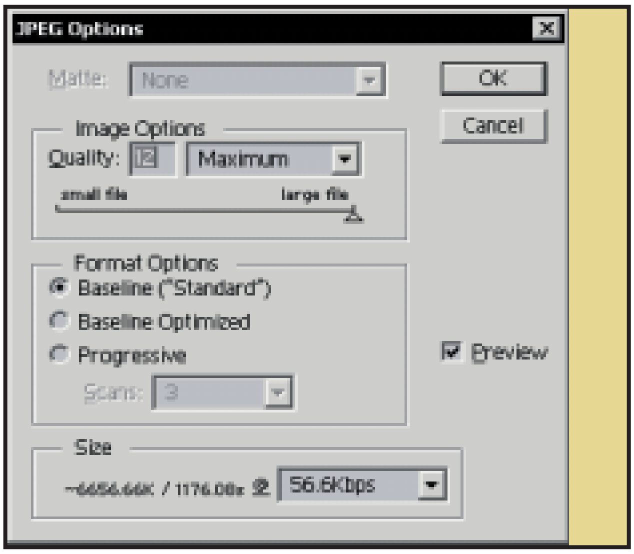
5 Once you've made your final scan, it's time to make any corrections or enhancements. We've scanned into Photoshop 5.5, but the picture is looking a little soft. Many scanner drivers offer a sharpening control, but if that doesn't work try the sharpening controls in most photo retouching packages. Photoshop boasts no fewer than four different types of sharpening, including the strangely-named but sophisticated and preferred Unsharp Mask pictured above. A preview shows what impact the Unsharp Mask filter will have on your image.

6 Check the histogram of a digital image to see the range of tones in the picture. Histograms are offered by most photo retouching packages and some sophisticated TWAIN drivers. This histogram shows the tonal information petering off before it hits the darkest shadows on the far left. If there are supposed to be dark areas, consider stretching the tonal information across the entire range of light and dark. Photoshop's Levels control, above, lets you do this automatically or manually by dragging the input level's triangles to the limits of the captured range.

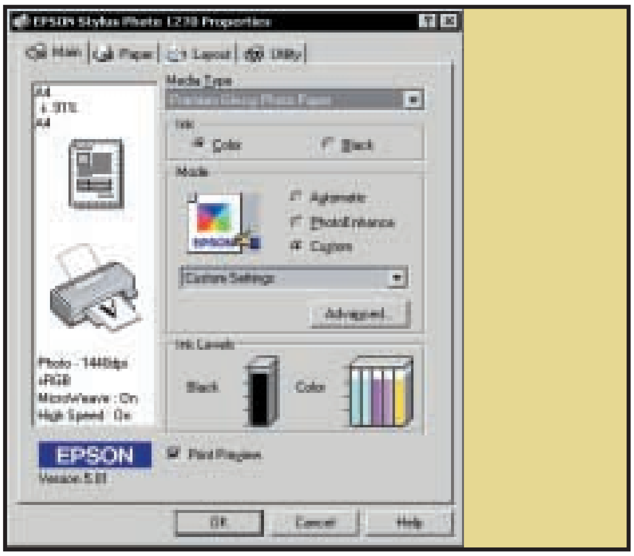
3 Previously we doubled the resolution, but as far as the scanner was concerned, we were still going to print it the same size at 12.80 x 18.16cm. To make the enlargement, we would change the resolution to 200dpi without altering the file size in Photoshop, forcing the physical printing dimensions to increase. However, it's easier to use the scaling function. Above we have left the resolution at 200dpi, but changed the scale from 100 to 200 per cent. The file size is 16.49MB, but the physical dimensions (used to instruct a printer) have doubled to 25.60 x 36.32cm.



4 If possible, the TWAIN driver is the best place to make tonal or colour corrections, before doing the final scan. At this point, most drivers will be working with the most possible image data, such as an increased tonal dynamic range, before normally delivering the most significant 24bits to your application. If you make brightness, contrast and colour adjustments after scanning, you may increase the level of noise or reduce the tonal dynamic range. This pre-scan stage is also where you should activate any de-screening options to eliminate moiré.



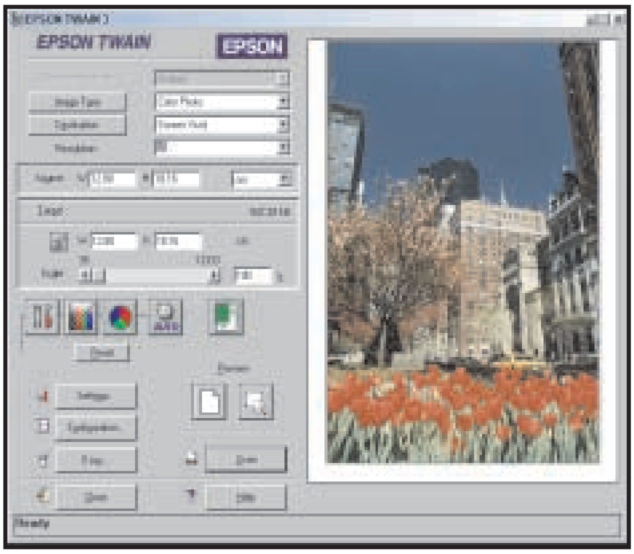
7 Once you've got this far you'll want to save your image. The big question is whether to compress or not. The JPEG format permanently throws away information, so is not suitable for archive. Try saving as a TIFF with LZW compression – this is lossless, so may not be as effective as JPEG, but you'll still save a little space without losing quality. Then again, try using JPEG compression at its mildest setting. Above we've set the slider to maximum quality, which has reduced the file size from 16.49MB to 6.66MB without any perceptible loss in quality.



8 Above is the printer driver for the Epson Stylus Photo 1270, which can hold your hand or let you tweak to your heart's delight. Most crucially, make sure your printer driver knows what kind of paper it's using, or you may end up with too much or not enough ink on the page. We've chosen custom colour settings in an attempt to match the colour properties of our scanner without messing around with ICC profiles. We've opted for sRGB (standard RGB), which is used by many devices to match scanner settings in order to get an accurate printout.

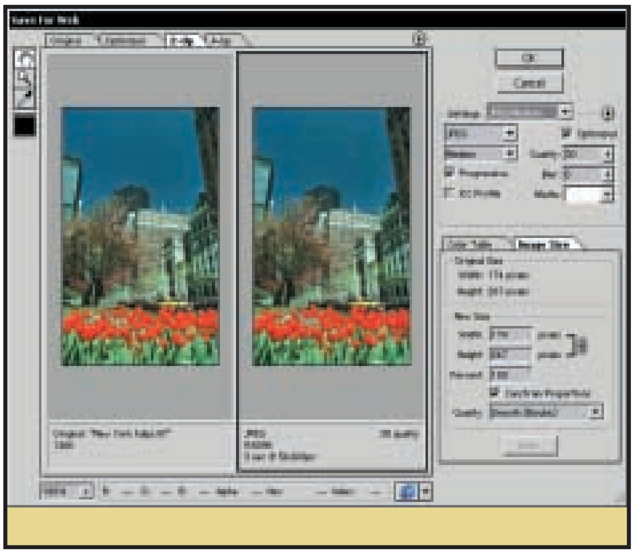
Scanning for the web

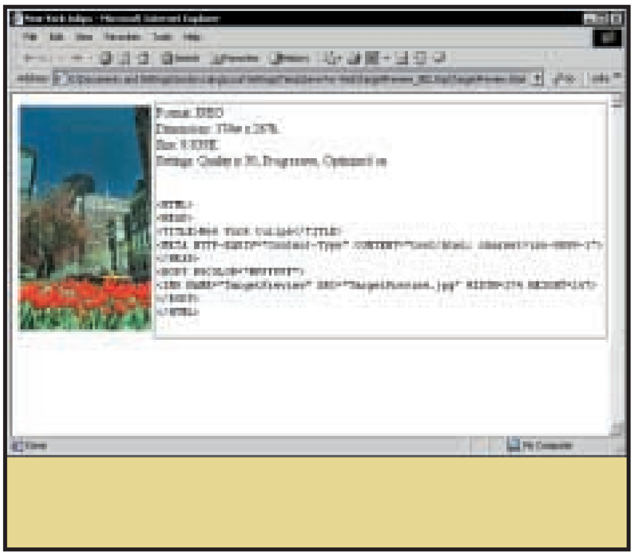
Size does matter when you put pictures on the Internet, so to avoid excessive download times, follow our advice



1 Scanning images for the web is pretty simple, with just two main considerations concerning image size. First, how big would you like the picture to appear on a monitor? Most monitors operate between 70 and 100dpi, depending on the desktop setting and the physical screen size. A typical 17in monitor measures about 13in across, and if it's running at 1,024 pixels, will have a display resolution of about 79dpi. Since each monitor pixel can perfectly display each scanner pixel, use this display resolution as a base. Above we've chosen 72dpi, with a file size of 547KB.

2 Since our original photo measures 5 x 7in, scanning it at 72dpi will reproduce it on screen at 5 x 7in. This is a bit big, so above we've halved its size using the scale to 50 per cent control. The new target size physically measures 6.4 x 9cm, and the corresponding file size has been reduced to 136KB. While you may think this is a bit small on screen, a picture 9cm tall is considered pretty big in website terms. Choosing the correct size for online publication takes a bit of practice, but generally, you'd be surprised how small most web pictures really are.





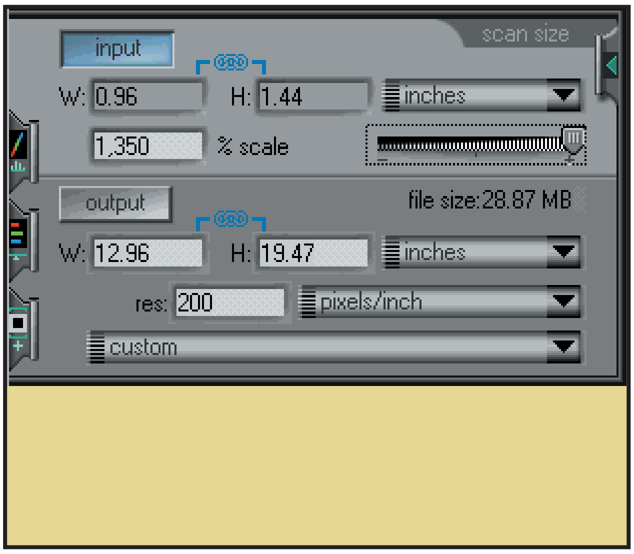
3 A file size of 136KB may sound small compared to the tens of megabytes mentioned in the printing workshop, but it's still too big for most websites. The trick is to use JPEG compression to reduce the file size without overly compromising image quality. Photoshop 5.5 has a superb Save for Web facility (above) that displays the original image next to one or three compressed versions for direct comparison. Going for medium quality, we've reduced the file size to just 9.8KB, which Photoshop estimates will take three seconds to download using a 56K modem.

4 Remember what we were saying about how big images can look when viewed in a web browser? The final step in preparing any image for web use is to preview it in a browser. You can either open your JPEG directly into a browser using its File menu, or you could go for a special preview mode in your image manipulation package. Above we've gone for Photoshop 5.5's Save for Web browser preview, which also shows the settings used, and even lists the HTML code used to display it. If the image is too large, consider reducing its physical size further.

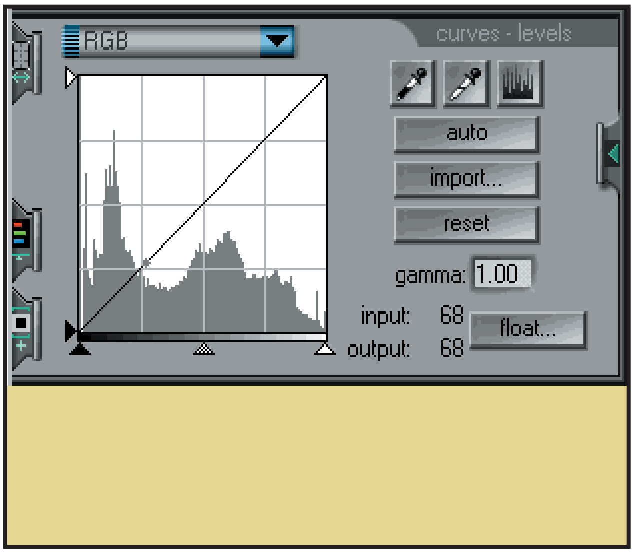
Film scanning

What if your favourite picture is in 35mm transparency format? Well, with a high-quality scanner you can get great results

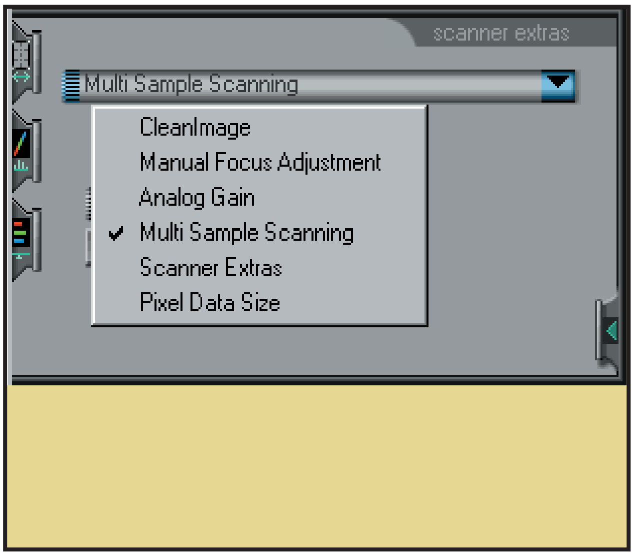
1 Scanning tiny frames of film can be a specialist business. Flatbed scanners can have transparency adaptors, but all they do is shine a light from above and do nothing to improve the unit's relatively low resolving power. Even with 1,200dpi of genuine horizontal optical resolution, you're only looking at a 6 x 9in 200dpi print from a 35mm frame and 3 x 4.5in from a 600dpi scanner. Consider a dedicated unit such as Nikon's compact but high-quality LS-2000 SCSI-2 model. The TWAIN driver v2.5 is sophisticated with many options for advanced users.



2 The first of the four main pull-out tabs sets the scanning resolution and image output size. The 'input' size reveals the small 0.96 x 1.44in size of a 35mm frame. By entering a desired output resolution of 200dpi for our colour inkjet, the driver calculates that a maximum 1,350 per cent scale increase will result in a print measuring 12.96 x 19.47in – A3 to you and me. At standard 24bit, the maximum file sizes from the LS-2000 are 28MB. Obviously you can go for smaller enlargements, or lower resolutions for more modest prints or online use.



3 The second of the four tabs reveals a fully-featured histogram facility. This indicates the range of tones present in the image and lets you automatically stretch them, or manually choose bright and dark points on the preview window. This histogram is for the photo in Step 1. The Nikon's default auto-exposure settings have produced a scan with a good range of tones, so no correction is urgent. The third settings tab offers sliders to adjust brightness, contrast and colour – the TWAIN driver is the place to make these adjustments for the best quality.



4 The fourth tab presents the advanced options. CleanImage spots specks of dust, small hairs and scratches – the banes of film scanning – and automatically retouches them. The results are excellent, but the final image is often a little soft, so there's also a Sharpen option. Pixel Data Size lets you switch from 8bit grey levels to genuine 12bit, although Photoshop will round this up to 16bit in its 48bit RGB mode. Multiple sample scanning makes four or 16 extra passes on the original, significantly increasing signal-to-noise ratio.