Adobe℠ Customer Services

Scanning Basics

This technical note gives an overview of scanning technology, issues that affect scanning results, and techniques that will help you achieve the best results when using desktop scanners. The note also discusses the types of scanners and other image-capture devices available.

Scanners play a pivotal role in today's digital imaging applications. These devices convert continuous-tone photographic prints and transparencies into digital images that can be manipulated on a computer. Although technology that allows cameras to capture images directly into digital form is under development, an understanding of scanning technology is important for users of current digital imaging software.

SCANNER TECHNOLOGY

Scanners work by reflecting light from or transmitting light through the photograph or transparency being scanned. The reflected or transmitted light is directed to the scanning head, which typically consists of an array of charge-coupled devices (CCDs) or light-sensitive diodes. A diode or device measures the amount of light striking it and uses this measurement to generate an intensity value between 0 and 255 for each of the three additive primary colors: red, green, and blue (RGB). The scanner then combines these RGB samples to produce a 24-bit, full-color image (8 bits for each primary color).

Scanners range from slide scanners, designed to scan transparencies, to low-end desktop scanners, which typically have a flatbed design, to high-end drum scanners, also called laser plotters, which are used by expensive color systems, such as Scitex™ and Crosfield™, that color separate images as part of the scanning process. Images can also be captured directly from image-capture devices, such as still-video cameras or digital cameras, and converted into digital data.

SCANNER TYPES

- Slide scanners, like those marketed by Nikon, Barneyscan/PixelCraft, and Kodak®, are designed to scan small-format transparencies such as 35mm slides and 2.25-inch transparencies at resolutions up to 4000 lines per inch. These scanners use linear arrays of CCDs to capture a single line of data at a time. Three passes, each using a different color filter, are made over the image to capture RGB information. This three-pass process increases both scanning time and the likelihood of motion-based scan lines and defocusing.

- Flatbed scanners, such as those from Microtek, Sharp, and Howtek, can accommodate reflective art in a variety of sizes and can also handle transparencies (using an optional transparency holder). The effective resolution of flatbed scanners is usually 300 to 400 dpi, although some can reproduce resolutions up to 600 dpi. Like slide scanners, most flatbed scanners make three passes over the image for a full-color scan.

- Drum scanners made by Isomet, Optronics, Crosfield, Diamechi, and other manufacturers are generally considered high-end, professional devices. The operator fixes the original artwork to a cylinder that spins in front of the scanning head, which also focuses a point of light onto the image. These devices generally use photo-multiplier tubes (PMTs) to record the light intensity. The consistency of the light beam and the accuracy of the focusing optics result in high-quality scans.

OTHER IMAGE-CAPTURE DEVICES

Still-video cameras capture images directly into NTSC video format, which video capture boards can convert into RGB data for computer manipulation. (Some so-called videographics boards can also digitize individual frames from videotape or from a live video feed.) The resolution of images captured from video is fixed at about 640 by 480 pixels, and color accuracy is greatly limited by the constraints of broadcast video standards. These two drawbacks limit the usefulness of video image capture in print applications.

A new digital camera developed by Kodak uses a standard Nikon F3 camera body that accepts all Nikon lenses. The camera converts the images directly into 24-bit digital data, at a resolution of 1024 by 1280 pixels. This is about the resolution needed for a 4-by-5-inch magazine-quality print. The camera is attached to a processing unit and hard disk drive that can store up to 160 megabytes of data (about 40 images). These digital photographs can then be loaded directly into a Macintosh computer.

ISSUES AFFECTING THE QUALITY AND ACCURACY OF A SCANNED IMAGE

A number of issues affect the quality and accuracy of the digital file captured during a scan, including the scanner resolution, dynamic range and illumination, focusing accuracy, and recognition of black and white points.

Scanner resolution

Most desktop scanners use CCDs. The density of the CCDs determines the scanner's resolution; the more CCDs in a given area, the greater is the scanner resolution as measured in dots per inch (dpi). Each CCD records color information and outputs one 24-bit color value. This value makes up an individual pixel in the digital image. The higher the resolution of the scan, the greater is the number of data points recorded, and the larger the file size.

A full-width scan along one axis is called a *line of resolution*. High-end scanners scan information as lines; they can achieve resolutions of up to 10,000 lines per inch. Desktop scanners, which scan information as dots (pixels), cannot achieve such high resolution; this is one of the obvious differences between high-end and low-end scanners. Typically, desktop scanners have a resolution of 300 dots per inch (dpi), which generally is high enough for reproductions of usable quality.

Dynamic range and illumination

Dynamic range is the range of discrete colors a scanner is able to distinguish. Variations in dynamic range impact the quality of the scan more than simple resolution does. High-end scanners are more sensitive to the range of colors in the spectrum and can record the minor differences between two almost identical colors. A scanner with a lower dynamic range records the two similar colors as the same value.

Several variables determine a scanner's dynamic range—pixel depth (number of bits per pixel per color), sensitivity of the CCD, accuracy of the focusing optics, and precision of the measurement of the black and white points.

Illumination can also affect the quality of the scan. For instance, CCD arrays require a consistent light source to illuminate the image evenly. Variations in illumination across the original can produce unwanted artifacts in the digital image.

Focusing accuracy

The accuracy with which light is focused onto the scanning head is one of the primary distinguishing qualities between desktop scanners and the high-end devices used in prepress houses. To receive the most accurate reading from any point on the image, CCDs in the scanning head require a finely controlled optical aperture.

In a scanner with excellent optics, the color information for one pixel in the original image is focused precisely onto one, and only one, CCD. This yields a very crisp scan with distinct colors. In a scanner with less refined optics, the pixel's original color information is diffused slightly across several adjacent CCDs. The diffusion tends to soften or muddy the colors and edges in the resulting digital image. Therefore, if one of the devices has better optics, two scanners with identical resolution and illumination characteristics can produce scans of radically different quality.

Because accurate focus is so important in scanning, any vibration or movement of the CCD degrades the quality of a resulting image. Such unwanted movement has the same effect as poor focusing optics. Motion during a scan can also create *image slips*, which occur if the movement of the drum or bed holding the original artwork is not smooth and continuous. In such a case, the scanned image has a seam or line through it. Image slips occur most often on desktop scanners.

Black and white points

The accuracy with which a scanner senses the original image's black and white points also greatly affects the dynamic tonal range of the final digital image. If a scanner does not accurately recognize the darkest point in an image and set that point as black (or does not let the user define it as black), the tonal range of the resulting digital file is lessened. A similar reduction in tonal range occurs if the scanner incorrectly determines the white point (the lightest point in the image).

Because most desktop scanners do not automatically seek an image's black and white points, these scanners generally clip the original image's dynamic range. Most high-end scanners automatically and accurately determine white and black points and spread out the range of tones to be scanned.

BEFORE SCANNNING

The choices you make before scanning an image will affect the quality and usefulness of the resulting digital file. Before scanning, consider the resolution at which the image will be scanned, determine the optimal dynamic range, and determine whether the image contains unwanted color casts that could be eliminated during scanning.

DETERMINING THE CORRECT SCAN RESOLUTION

The most important consideration in assuring the quality and usefulness of the scanned image is determining the correct resolution for your scan. The optimal resolution depends on how the image will be printed or displayed. For example, if the image will be used as a screen display, then its resolution need not be greater than the resolution of the target screen area–about 640 by 480 pixels. On the other hand, if the final image will be a full-bleed magazine cover, you'll need considerably more data to work with.

If the image resolution is too low, the PostScript™ language may use the color value of a single pixel to create several halftone dots. This results in pixelization, or very coarse-looking output. If the resolution is too high, the file contains more information than the printer needs. The file size directly affects how long it takes Photoshop to process the image, and the printer to output the image. The size of a file is proportional to its image resolution. For example, the file size for an image with a resolution of 200 ppi is four times greater than an image of identical dimensions and a resolution of 100 ppi. Your goal is to balance ideal resolution with a manageable file size.

The scanning resolution of printed output depends on the target line screen as well as on the resolution of the printer and the size of the original document compared to the scanned image. Because different color-separation software utilities suggest different pixel-to-line-screen ratios, it's best to check with your service bureau and print shop before scanning.

A good rule of thumb for images that will be color separated is to capture pixels at twice the line frequency of the screen to be used for printing. For example, if you are producing a magazine cover that measures 10 inches tall by 7 inches wide and will be printed using a 133-line-per-inch screen, a good scanning resolution would be 2660 pixels for the height (133 lpi by 10 inches by 2 inches), or 266 ppi. Note that if your image resolution is more than 2.5 times the screen ruling, you will get an alert message. This means that the image resolution is higher than the printer can accommodate and is unnecessarily increasing the file size and print time.

The size of the final image compared to the original image is also a consideration in setting scan resolution. When making the image larger, additional data is necessary to produce a final image with the correct image resolution. If the final image will be smaller than the original, less data is needed. Determine what the file size must be to contain the pixel information by creating a dummy file in Photoshop. For more information, see Chapter 2, “Scanning, Importing, and Exporting,” in the *Adobe Photoshop User Guide*.

DETERMINING THE OPTIMAL DYNAMIC RANGE

Because the human eye can detect a wider tonal range than can be printed, consider adjusting the scanning parameters to pick up the details that are of the most interest in the final image. However, because each primary color has to be assigned a discrete value between 0 and 255, limiting values to a certain range may cause valuable detail to be lost. Some scanners can capture 12 bits per pixel per color, which allows them to capture a larger range of detail. Emphasize specific tonal areas in the image by carefully setting the white and black points in an image before scanning it.

COMPENSATING FOR AN UNWANTED COLOR CAST

Before scanning, determine whether the original image has an unwanted color cast that you might be able to eliminate during the scan. Use the following procedure to make sure that the scanner itself is not introducing a color cast. While color cast is sometimes used for aesthetic effect, it’s typically an undesirable artifact when it is created as part of the scanning process.

To ensure that the scanner is not responsible for an unwanted color cast:

1 Calibrate your monitor using the Gamma CDEV included in Adobe Photoshop or a monitor calibration utility. For more information about this process, see Chapter 15, “Calibrating Your System and Producing a Separation,” in the *Adobe Photoshop User Guide*. Calibration compensates for any color casts and shifts in gamma caused by the monitor display. It is critical to calibrate your monitor before attempting the following test.

2 Create a file in Photoshop containing an 11-step gray wedge. (Or use an 8-inch by 10-inch, 18% neutral gray card and an 11-step gray wedge purchased from a photographic supply store for this test.)

3 Print the file, and then scan the printed output back into Photoshop in the RGB or CMYK mode.

4 Using the Info palette and the eyedropper tool,sample the grays in the image to see whether they contain any hue or color tint. If the grays contain a hue or color tint, then the scanner is adding a color cast.

5 Use Photoshop’s Levels controls to eliminate the color cast, and record the resulting gamma and the white and black point settings.

6 Using the controls (or plug-in module) provided with your scanner, use the values recorded in step 5 to compensate for the color cast. Rescan the gray wedge to verify that the cast has been removed.