CHAPTER 13

Digital Photography

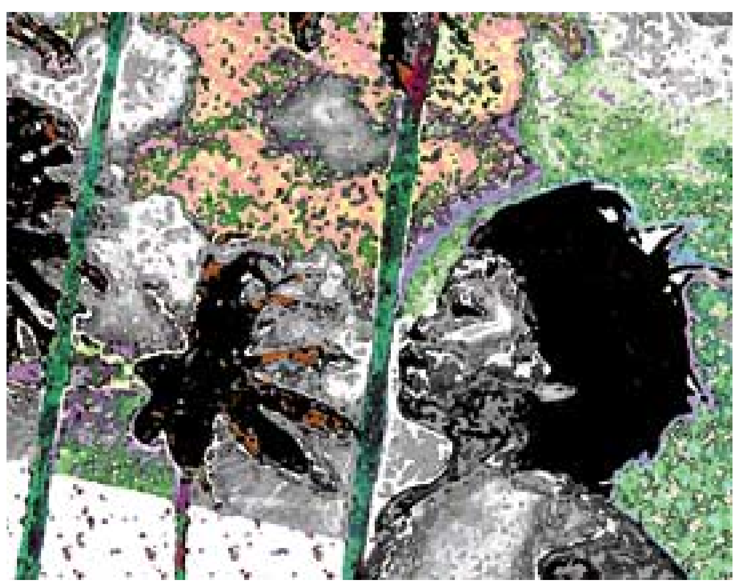
Peter Garfield, *Siren*.

Digital Darkroom. This is a modern, chemical-free darkroom using digital images. When performing color correction, black-out drapes are placed over the windows to control room illumination.

Electronic photography is the production, viewing, or reproducing of photographic images by electronic means. Today it is possible to produce photographs entirely electronically, without the use of traditional silver-based photographic materials. The method used for the electronic production of higher quality images is to convert them to digital (numerical) form, so the electronic imaging process is often called **digital imaging.**

In the past few years, the use of electronic imaging in photography has become increasingly important. In the publishing industry electronic imaging has been in use for many years, and nearly all published photographs are reproduced at some stage in electronic form. As the equipment for digital imaging has improved, more photographers are using electronic cameras to produce original images without the use of traditional films. Digital original photographs are being used in catalog production, forensic photography, scientific photography, photojournalism, industrial photography, and other fields. The use of electronic cameras has also begun to make inroads into the consumer-based snapshot industry, with a number of easy-to-use digital cameras currently on the market. While today most photography is still done on traditional films with conversion to electronic form as needed, technological advances will soon make electronic photography the most common method of producing photographic images.

There are advantages and disadvantages to digital photography, when considered in the light of current technology. Digital images can retain their original quality no matter how often they are copied electronically. Traditional photographic quality deteriorates markedly with each generation of copying. Digital images also offer remarkable opportunities for manipulation of the image. Since digital images are recorded as numbers, computers can be used to alter them in ways that are difficult or impossible with traditional photographic materials. On the negative side, current digital production methods require very expensive and cumbersome equipment and materials to match the reproduction quality of even small-format, traditional photographic materials. The possibility of achieving a digital camera that approaches the convenience and quality of film-based systems improves with each technology advance, and we may soon have a reasonably compact, moderately priced digital camera that can compete with film.



Maria Eugenia Poggi. Jijoca de Jericoa coara, Ceara, Brazil, July, 1994. This is a digitally manipulated and produced photographic image.

In spite of the disadvantages, digital photography already has very real applications at different stages in the production of photographs. While you may not find the cost and awkwardness of digital original equipment to your liking, you may be able to use electronic images at other stages in making photographs. Many photo labs offer quality photographic printing using digital means. Certainly, if any of your photographs are reproduced on ink-based presses, they will be converted to digital form before printing.

If you are intrigued by the possibilities of digital imaging and would like to get started, this chapter is designed to give you the information to acquire the equipment, materials, and knowledge that you will need.

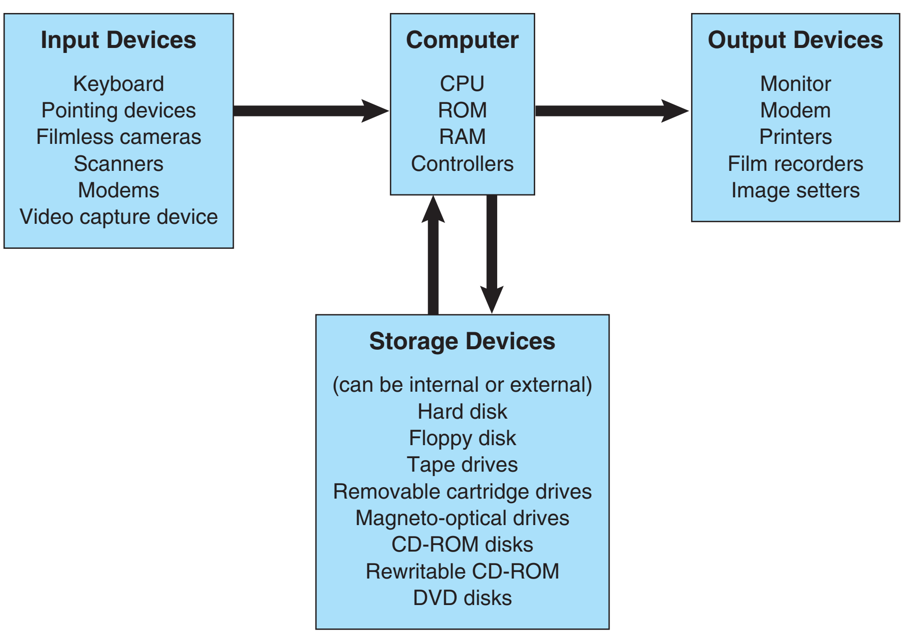
Computers and Computer Terminology

The major tool used for handling digital images is the computer. A computer is a device with electronic solid-state switches that can do calculations with numbers, or anything that can be represented as numbers. Since digital images are numbers, the computer can be programmed to view, store, and manipulate the image.

To work with digital images you will need the following **hardware** (the devices used to work with the images) and **software** (the instructions the computer uses to manipulate images).

Hardware

The following flowchart diagrams the equipment you might use to capture and process digital photographs. In general, hardware can be divided into four categories: (1) the computer; (2) input devices; (3) output devices; and (4) storage devices.



Computer. This case contains the CPU, a hard drive, a CD-ROM drive, and other electronic control circuitry.

Computer The computer contains the **central processing unit (CPU)** and other electronic circuitry for performing the computations (see the boxed section "How a Computer Calculates"). The case for the computer usually also contains one or more data storage devices and allows the attachment of input and output devices, known as **peripherals.** There are several types of computers available, but the ones most widely used are the Macintosh and the IBM-PC or compatibles of these. The CPU has associated with it a **clock speed,** which partially determines the speed with which a computer does calculations. The clock speed is given in megahertz, which means million cycles (calculations) per second.

Read-only memory (ROM) is data permanently stored on solid-state chips in the computer, and provides the instructions the computerneeds to startself tostart itself when it is turned on.

Random access memory (RAM) consists of solid-state chips in the computer that the computer uses to temporarily store data while it is working. If the computer is turned off or power is interrupted, any data in RAM is lost. The amount of RAM a computer contains determines how many tasks a computer can perform at one time, and also has a major effect on the speed of operation.

Controllers are devices in the computer that interface with storage and other devices. The computer also contains circuitry and dedicated memory needed to run the video monitor attached to it.

Input Devices. The keyboard and mouse provide a way of inputting information and commands to the computer.

Input Devices Input devices feed data into the computer. Some input devices are used to directly control and input data, such as the keyboard and pointing devices (mouse, graphics pad, track-ball, joy-stick, etc.). Other input devices are specialized to provide the computer with digital files, for example digital cameras and scanners (see pages 373–74). **Modems** are input devices that allow digital data to be sent to your computer via telephone lines.

Output Devices Output devices receive data from the computer and display or process it in various ways. The video monitor is an output device that allows you to view directly images generated by the computer. Also in this category are devices that print on paper or film (see pages 390–91). Modems are also an output device, allowing data to be sent from your computer to other computers via telephone lines.

Storage Devices Storage devices record digital data in a form that can later be recalled by the computer (see page 377).

Software

Software is the set of instructions (a **program**) that is used to direct and manage data computations on the computer to perform specific tasks. The software that determines the interface between the computer and the operator is called the **operating system.** The two types of computers mentioned earlier (Macintosh and IBM-PC) have their own operating systems. Programs that are designed for specific functions (like word processing, spreadsheet management, or digital image manipulation) are called **applications** and must be written to work on specific operating systems (sometimes called **platforms**). Programs are not interchangeable between platforms.

What You Need to Get Started

To work with digital images, you will need at a minimum a reasonably fast computer with sufficient RAM and data storage to handle digital images. Dig-

How a Computer Calculates

The heart of the computer is the central processing unit (CPU). The CPU is a solid-state "chip" that does the actual computation. Since the electronic switches in the chip can only indicate "off" or "on," each switch can represent just two digits, 0 and 1. For that reason, computers calculate numbers in binary (base 2) form. Starting from the right, in a binary number the first digit represents units, just as in base 10, allowing us to count 0 and 1. Since we are now out of numbers, the next digit to the left is used to represent 2s. The third digit from the right represents 4s (2 × 2) and so on. The chart at the right shows how the binary numbers compare to base 10 numbers. As you can see, it takes eight binary digits to count from 0 to 255.

Each binary digit is called a **bit.** Eight bits are called a **byte** and can represent up to 256 numbers (0 through 255). In digital imagery, an eight-bit binary number can represent 256 shades of gray or 256 colors. The amount of data it takes to represent an image is given in bytes or multiples of bytes. The data is stored together as a **file.** The size of the file depends on how many numbers are associated with the image. ■

BASE 2		BASE 10
0	=	0
1	=	1
10	=	2
11	=	3
100	=	4
101	=	5
110	=	6
111	=	7
1000	=	8
•		•
•		•
•		•
11111111	=	255
100000000	=	256

8 bits = 1 byte
1024 bytes = 1 kilobyte (KB)
1024 KB = 1 megabyte (MB)
1024 MB = 1 gigabyte (GB)

ital image files can vary from less than 1 megabyte to 100 or more megabytes, depending on size and quality desired. You will also need digital image processing software. There are several companies that publish digital imaging software, such as Adobe Photoshop. Photoshop is a sophisticated professional program, but there are many other smaller and less expensive programs that perform many of the image processing tasks you need.

If you don't have a digital camera or scanners, you needn't go right out and buy them, since there are service bureaus that can make digital scans for you from your existing traditional negatives, slides, or prints. One of the least expensive ways to get your photographs digitized is the Kodak Photo-CD, offered by most photofinishing labs (see page 374).

You will probably also want a computer printer, such as a high-quality inkjet printer, so you can make printed versions of your digital photos. Service bureaus can also provide print output from your digital files in a variety of materials and processes (see pages 390–91).

More detail about hardware and software can be found in the following sections.

Basic Computer Workstation.

■ Overview of Digital Imaging

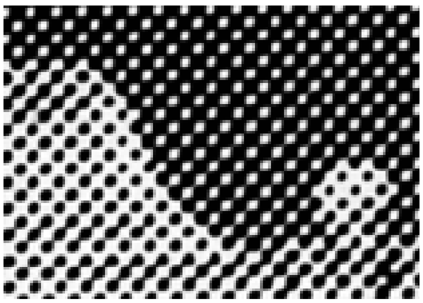
The five basic stages of image production are: (1) creating the image; (2) storing the image; (3) viewing the image; (4) editing (modifying or correcting) the image; and (5) outputting the image.

These stages apply to traditional photographic reproduction as well as electronic imaging, though the order of the steps may vary depending on the material being used. Electronic imaging can be used at any one of these stages, with traditional means used for the remainder. For example, a photograph might be created, stored, viewed, and edited electronically, but output onto traditional materials (film or photographic paper) using digital output devices. On the other hand, the photograph can be created traditionally on film, which is then scanned to produce a digital image, and the remaining steps are performed electronically. We will deal with each of these categories in detail.

Creating Digital Images

For more on half-tone processes, see pages 271–72 and 498–502.

The methods used for creating an electronic image are a derivation from the concepts used in half-tone printing. Printing devices that use ink can technically only create two tones—ink or no ink. They are incapable of providing the continuous shades that a photograph contains. To simulate these shades of gray, the half-tone process converts the photograph to a grid-work of dots. The dots vary in size, with large dots used to represent darker tones, and smaller dots used to represent progressively lighter tones. If the spacing of the grid is fine enough, the eye blends the dots into intermediate tones. The more dots that appear per inch, the finer the quality of the image appears to the eye. Television images also make use of this concept. They are electronic images that consist of dots as well, but in this case the dots vary in brightness rather than size to simulate differing tones. Color can be reproduced in dot-based images by providing three dots that represent the amounts of the additive primary colors (red, green, and blue, indicated as RGB) or subtractive primary colors (cyan, magenta, and yellow usually used with black as well, indicated as CMYK).

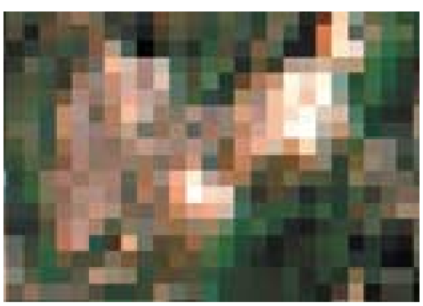


Half-tone Dots.

Early electronic still photographic images were based on the same technology as television/video. The optical image fell on a grid of light-sensitive elements, which sensed the amount and color of the light at that point. This information was recorded in **analog** form, which means that the illuminance values were represented by something else, like electrical voltage or magnetic patterns on tape.

Digital Image Structure

A similar dot technique is used for creating digital images. In a digital camera, the optical image formed by the lens falls on a solid-state electronic "chip" that contains a grid of light-sensitive elements, usually **charge-coupled devices (CCDs).** Each element, called a picture element or **pixel** for short, can measure the illuminance ("brightness") and the percentage of the additive colors of the light falling on it. This information is recorded as numbers. Each pixel has several numbers associated with it:



Digital Image Magnified Enough to See Individual Pixels.

1. Its position in the grid. This requires two numbers, one each for its horizontal and vertical positions.
2. Three numbers that describe the amount of red, blue, and green light falling on that pixel.

All of these numbers are recorded as digital data on computer storage devices. In order to view an image stored as numbers, the data must be used to create an analog image by reassembling the grid of pixels in a visible form, such as on a computer monitor or a computer printer. Images stored in analog form (e.g., video images on tape) are susceptible to magnetic and electrical noise, and deteriorate when copied. Images stored in digital form are files of numbers, and can be copied without distortion or deterioration.

Resolution The quality of a digital image depends on how many pixels it contains and the size at which it is reproduced. The combination of total number of pixels available in an image and the size at which it is output results in a specific number of pixels appearing per inch (ppi) or centimeter, known as the **resolution.** The higher the resolution of an image (i.e., the more pixels appearing per inch), the better the image can reproduce detail.

Image Size in Pixels The dimensions of the image in pixels are a major consideration when choosing a method of creating digital images. As a basis of comparison, consider outputting a digital image on an offset printing press. The digital image should have a resolution about twice the half-tone line screen for optimum quality. For example, many good-quality magazines print at 150 lines per inch, so the digital image must have a resolution of 300 pixels per inch. That means an image that is 600 × 900 pixels would print at only 2 × 3 inches. In order to print at 8 × 10-inch size, the image must contain 2400 × 3000 pixels.

Other types of output devices, such as computer printers or digital enlargers, may require less than 300 pixels per inch, meaning that larger images can be output from a file of given pixel dimensions. On a device that requires only 150 pixels per inch, the 2400 × 3000 pixel image could print at 16 × 20 inch size.

There are two methods for creating digital images: (1) original digital images can be created with a **digital (filmless) camera,** and (2) photographs created using traditional materials and equipment can be converted to digital form with **scanners.**

Point-and-Shoot Digital Camera. This camera uses flash card media, shown beside the camera.

Digital Cameras

As described above, a digital camera contains a grid of tiny, light-sensitive solid-state elements that record the illuminance and color of the image at each point. The number of pixels in this grid is the major determinant of the quality of the digital image. The larger the number of pixels, the higher resolution or output sizes the camera is capable of providing. Digital cameras fall into one of three categories:

Professional 35mm-based Digital Camera.

Low-Resolution Cameras These cameras produce images with relatively few pixels, generally around 640 × 480 pixels. They typically take the form of traditional point-and-shoot cameras, being very compact and featuring automatic focus and built-in automatic flash. Because of the small number of pixels available, images from these cameras are suitable only for small print output or for use where the images are viewed primarily on a computer monitor, as with the World Wide Web or CD-ROMs.

35 mm-based Digital Cameras These are cameras designed for professional use, and provide digital images of about 1200 × 1600 pixels or more. They are based on traditional 35mm camera models, and have the advantage that they use the lenses developed for those models and are reasonably compact. Currently these cameras are quite expensive compared to traditional cameras, costing several thousand dollars and up.

Digital Camera Backs These replace the backs on professional cameras, usually medium and large format. When used in a 4 × 5-inch view camera, a digital back can produce images with enough pixels to compete in quality with film in poster-size prints or larger. Digital backs are quite expensive and may be slow in operation, and may require the use of expensive, steady-state continuous lighting in the studio.

Digital Back for Use in a 4 × 5 View Camera. The digital back is inserted into the camera where film holders would normally be placed.

Scanners

Flat-bed Scanner.

If you don't have thousands of dollars to spend on the higher quality digital cameras, you will probably be scanning traditional photographs to create digital image files. A scanner is in some regards like a digital camera. It contains a chip with a grid of light-sensitive elements and a light source to illuminate the photograph. The light-sensitive chip is passed over the photograph to successively "scan" it and record the light values and color for each point of the image as a digital file. There are several types of scanners you may use to scan your photographs.

Flat-Bed Scanners Flat-bed scanners look something like a photocopier. Most will do a good job of scanning photographic prints. Some flat-bed scanners also have the capability to scan transparent photographic materials, such as negatives or slides. The resolution of the scanner refers to the number of pixels it can create per inch of the original. When comparing scanners, only **optical resolution** should be considered. Some scanner manufacturers advertise higher resolutions that are interpolated. **Interpolation** means that new pixels are mathematically created between the "real" optical pixels that the scanner produces. Interpolated resolution does not give as good a quality image as the equivalent optical resolution.

The optical scanning resolution of the scanner and the size of the original photograph determine the number of pixels in the digital image. For example, a 4 × 5-inch photograph scanned at 300 dots per inch produces an image 1200 × 1500 pixels in size. Some models of flat-bed scanners are the least expensive scanners available, but will scan at 300 to 600 dots per inch. That means that quality output can be achieved for the same size as the original, or two to four times as large as the original depending on the image resolution demanded by the output device. If the original is quite small, the number of pixels in the resulting image is small as well. A 35mm negative (about 1 × 1-1/2 inches) scanned on a flat-bed scanner with a transparency adapter at 600 pixels per inch yields an image of only 600 × 900 pixels. This is fewer pixels than some "snapshot" digital cameras provide.

Film Scanner for 35mm Film.

Film Scanners These scanners are designed specifically for scanning negatives and transparencies directly. They may be designed for small format (35mm and APS) films only, or may take larger formats as well. Most film scanners scan at 2000 pixels per inch or higher, providing image pixel dimensions of 2000 × 3000 pixels or more and start at prices of a few hundred dollars.

Drum Scanners These are capable of scanning prints or transparent materials at resolutions of 4000 or more pixels per inch. Because of their high cost and relatively difficult operation, drum scanners are generally used only by service bureaus, which can supply scans at a per-scan cost.

Kodak Photo-CD An inexpensive alternative to drum scans is the Kodak Photo-CD, which provides five scans of each image on a CD-ROM disk, the largest of which is 2048 × 3072 pixels. There is also a Pro version of the Photo-CD that includes an extra scan of 4096 × 6144 pixels for larger or higher resolution output, from films up to 4 × 5 inches. The Pro Photo-CD is, however, much more expensive per scan, though still considerably cheaper than drum scans.

Kodak Photo-CD.

Storing Digital Images

Decisions about how to store (**save**) your digital images are governed by the size of the data files, the speed with which you can record and read the data, and the amount of money you wish to spend on storage media.

Bit Depth

The bit depth for an image refers to the number of bits of data that are given for each pixel, and determines the number of shades or colors that can be represented. A single bit image has one binary digit per pixel and can only show two colors or shades per pixel (e.g., black and white). In a grayscale image using 8 bits per pixel, 256 shades of gray can be represented. A variation of 8-bit depth is **indexed color,** in which each of the 256 numbers is assigned a specific color, giving up to 256 possible predetermined colors. A 24-bit RGB image has 8 bits per color and the total combinations give 16,777,126 possible colors. Some scanners provide images with higher bit depth, but most image editing software will not handle more than 8 bits per color channel. Increasing the bit depth past 8 bits also increases file sizes and makes the images harder to manage. ■

Bit Depth of 1, Giving Two Tones or Colors.

Bit Depth of 8, Giving 256 Tones or Colors.

Bit Depth of 24, Giving 16,777,216 Tones or Colors.

File Size

File size depends on the number of pixels in the image, the **color mode—grayscale** (monochrome), **RGB color,** or **CMYK color**—of the image, and its **bit depth** (see the boxed section on bit depth). The position of each pixel in the image grid is indicated by its position in the data file, so no numbers are required for its coordinates. For example, a file might list the data for the pixels in order from the upper left corner. The illuminance values, however, must be recorded for each pixel. If the image is grayscale (8-bit monochrome), one 8-bit number (one byte) is needed to describe the tonal value of each pixel. For example, an image that is 400 × 600 pixels contains 240,000 pixels. The data needed for a grayscale image is:

$$240{,}000 \text{ pixels} \times 1 \text{ byte/pixel} = 240{,}000 \text{ bytes} = 240 \text{ kilobytes.}$$

Note: To be perfectly accurate you must divide by 1024 to change from bytes to kilobytes, or from kilobytes to megabytes. For simplicity, most people divide by 1000, as has been done in these calculations.

If the image is in 24-bit RGB color, then three 8-bit binary numbers are needed for each pixel (one each for red, blue, and green) to record its tonal information. The 400 × 600 pixel images would then require:

$$240{,}000 \text{ pixels} \times 3 \text{ bytes/pixel} = 720{,}000 \text{ bytes} = 720 \text{ kilobytes}$$

Larger output or higher resolution requires a greater number of pixels. An 8 × 10-inch 24 bit RGB image at a resolution of 300 pixels per inch would need 2400 × 3000 pixels, with a basic file size of 2400 × 3000 pixels × 3 bytes/pixel = 21,600,000 pixels, which is 21.6 megabytes.

File Formats

TIFF: Tagged-Image File Format. This is the most popular image file format, output by many scanners and accepted by service bureaus. TIFF format offers a lossless compression scheme known as LZW.

Photoshop (PSD): This is a file format designed by Adobe specifically for use in Photoshop. It supports the many features, such as layers and channels, which are available in Photoshop. It provides lossless compression. Photoshop can also save files in other formats.

JPEG: The Joint Photographic Experts Group (JPEG) developed this compression format to provide small files. It has different quality levels that control the amount of compression. It is a "lossy" format, but using the higher quality settings will reduce data loss somewhat.

PICT: Picture File Format, offering lossless compression and often used in multimedia applications. PICT can be used in combination with JPEG compression, in which case data loss is suffered.

EPS: The Encapsulated PostScript (EPS) file format is designed to provide page layout information to postscript type printers, and contains information for the printer.

GIF: Graphics Interchange Format, designed for use on the Internet. GIF provides lossless compression for images up to 8 bits (grayscale or indexed color).

PDF: Portable Document Files. Compressed versions of files that can be transported across the Internet and read by PDF readers such as Adobe Acrobat Reader. ■

Comparison of File Sizes for Different File Formats*

EPS	3.3 MB	JPEG Maximum Quality	637 KB
TIFF uncompressed	2.3 MB	GIF (Indexed Color)	540 KB
Photoshop (PSD)	2.2 MB	JPEG Medium Quality	168 KB
TIFF LZW compression	1.6 MB	JPEG Minimum Quality	101 KB

*From a 24-bit RGB image 800 × 1000 pixels with no extra channels or layers.

File Formats

There are several different file formats, and many of them have other information in them besides the image data (see the boxed section on file formats). For example, most files have a "header" that contains information about the file type, its name, creation information, color management information, and sometimes printer language information, as in the EPS file format. This additional information increases the size of the file.

Another factor in file size is whether or not the file is compressed. There are two basic types of compression, lossless and "lossy." Photoshop uses a lossless type of compression in its file formats. TIFF format also offers a lossless compression known as LZW. The JPEG file format, on the other hand, is a "lossy" compression, since it throws away data on compression, and attempts to reconstruct it on decompression. One disadvantage to any compression method is that opening and saving files takes more time.

Storage Methods

Once you know the basic size of your files, you can then decide which of the many storage devices are most appropriate for you. A few of the currently available technologies are discussed here.

Hard Disk The hard disk built into your computer would normally be a first choice, but if you are working with large or high-resolution digital images, you may fill up even a large hard disk drive quite quickly. Hard drives are also relatively expensive storage per megabyte, though they are among the fastest in terms of data retrieval. Hard disks can be internal (built-in) or external.


Internal Hard Disk Storage Device.

Removable Media Removable media offer the advantage that with one drive you can get unlimited storage by simply buying more media. There are two main categories of removable storage drives, magnetic or optical. Magneto-optical drives are a combination of the two technologies.

Currently available magnetic media include floppy disks, tape cassettes, and cartridge disks. Tape drives provide the lowest cost per megabyte, but are extremely slow in retrieving data. For that reason, tape drives are mostly used for continuous data backup in business applications. Floppies, while cheap, store only 1.4 megabytes per disk, so the cost per megabyte is actually quite high. They are too small to save high-resolution images. Disk cartridges offer larger amounts of storage, from 100 megabytes up to 2 or more gigabytes. These are a good alternative for image storage. Some of them are quite rapid in data retrieval as well, comparing with slower hard drives.

Optical storage offers very low costs per megabyte. The original CD-ROM recordable disks are very inexpensive and offer 650 megabytes of storage per disk, but require a special drive to record on them. Once the data is recorded, it cannot be erased or altered. Rewritable CD-ROM offers a disk that can be altered or erased, but at a much higher cost per disk. The newer DVD format offers much more storage on the same type of disk used for CD-ROM, but requires special drives. Optical drives are very slow in recording and retrieving data compared to magnetic disk drives.

External Zip Drive with Removable Media.

Memory Cards Digital cameras and some portable computers use memory chips designed to record data. These may be removable, and are often called **flash cards** or **PC** (formerly PCMCIA) **cards.** Flash cards are very compact, but are extremely expensive per megabyte, and are generally used only for transporting the image from the point of creation to your computer.


Flash Card Removable Media. On the left, a card is seen partially inserted into a digital camera. On the right is a flash card reader that can be attached to a computer for direct access to the images on the card.

Choosing a Storage Method

It is best to wait for major purchases of storage drives and media until you have a good idea of the type of digital imaging you are going to be doing. Once you know the approximate file size and number of your images, you can balance the cost of the drive itself, cost of removable media, speed of recording and retrieval, and convenience of the media. If you plan to use service bureaus for scanning or other services, you should inquire what removable media they support. New solutions to data storage appear regularly, so consult recent catalogs or vendors for the latest ones before you buy.


Monitor for Use with Computers.

Viewing Digital Images

Monitors

The computer monitor is the device used for viewing the digital image while you are working on it on the computer. Most current models of monitors are of the **cathode ray tube (CRT)** type, but the **liquid crystal display (LCD)** screens that have been used for several years in portable computers are now also available for desktop use.

The factors to consider when purchasing a monitor are its size and the quality of its image. Screen size is measured diagonally. Large screens are very convenient for digital imaging, since in addition to the image itself, the screen must display menus, tool boxes, and other information.

Screen Resolution

Computer monitors produce a video image, which consists of dots of red, blue, and green light. The dots are used to represent pixels on screen. The resolution of the monitor is the number of pixels it can display horizontally and vertically. Standard resolutions are 640 × 480, 832 × 624, 1024 × 768, and 1280 × 1024 pixels. The resolution of most modern monitors is adjustable. While it may sound advantageous to run a monitor at its highest resolution, in fact, the type, menus, and information boxes displayed on the screen will appear smaller at higher resolutions. That means you can fit more on your screen, but you might be straining your eyes to see the information. A 17-inch monitor at 832 × 624 pixels gives comfortably sized type and menus. People with good close-up vision may be able to work at 1024 × 768 pixels as well.

Video Boards

The computer monitor is run by a video controller with its own memory dedicated to displaying the image. Computers come with a built-in video control board and video memory. Unless the computer was designed for imaging work, you may find that the built-in video controller is inadequate for working on digital photographs, resulting in slow screen displays and scrolling. In that case, you can purchase an accessory video control board with additional memory to speed things up.

Editing Digital Images

Editing a digital image means correcting tonal values, color, detail, and image flaws. It can also mean manipulating the image by combining it with other images or applying special effects to radically modify the appearance of the image.

Image-Editing Possibilities

Traditional printing techniques are covered in chapters 5, 12, and 14.

There are many parallels between traditional and digital photography in the editing stage. Traditionally, the editing steps take place in print making and post-printing operations. For example, in the printing process the lightness and darkness and the contrast of the image can be modified by exposure and contrast control techniques. Local lightness and darkness can also be controlled by local exposure (burning and dodging). In color photography, there is little control over contrast, but the overall color balance of the image can be modified by filtration.

In addition to the standard enhancement techniques, a number of traditional special techniques can be used to change the appearance of the image. Two or more images can be combined into one using multiple exposure or printing techniques. Sabbatier, posterization, or other techniques can be used.

See chapter 11 for information on traditional special techniques.

Digital image editing can do all of the above, and more. Changing the overall lightness/darkness and contrast is easy to accomplish. Local areas can be selected for changing their lightness/darkness, and can also be individually controlled for contrast and color balance, effects that are very difficult to achieve traditionally. Special effects routines (called **filters**) in digital imaging may mimic traditional special effects (such as sabbatier effect or posterization) or may produce new effects that are impossible to achieve traditionally. Controls over image sharpness, such as simulated motion blur or focus differences, are grouped with the special effects filters. A special strength of digital imaging is its ability to seamlessly combine two or more images into one.

Once you experience the amount of control, flexibility, and visual possibilities digital image editing offers, you may find it hard to go back into a chemical darkroom. Nevertheless, currently it is difficult or impossible to achieve print output from the computer that matches the reproduction and visual qualities of some of the traditional printing materials, like high-quality black-and-white silver papers, platinum prints, and other traditional materials. Many photographers, however, are using digital imaging as an intermediate stage for producing prints on traditional materials. Most nonsilver processes, for example, require an enlarged negative for contact printing, which can be created using digital methods.

Howard W. Kreiner, *Busch Garden Fantasy.* This is a photograph with special effects applied using digital imaging software on a computer.

Image-Editing Software

The software that makes it possible to perform editing operations on a digital image using the computer is called image-editing software. Adobe Photoshop is an example of professional image-editing software. There are numerous other brands on the market, but most of them closely emulate the basic operations of Photoshop, though they may not offer as many features.

Image-editing software in general is demanding of computing resources, such as hard disk space and RAM. The hardware requirements given by the software manufacturer are a minimum requirement, so if you will be working with large files you will want to increase your memory and storage space above the manufacturer's requirements. A general guideline for Photoshop is to have at least three times as much RAM as the image file size. For example, if you want to work with a 20-megabyte file, you should have at least 64 MB of RAM for Photoshop plus more memory for the operating system or other applications you may wish to run at the same time.

Image-Editing Tutorial

The following tutorial will guide you through some of the digital editing possibilities. We will start with the tools and filters that are useful in producing straight, unmanipulated images, such as tonal and color controls, as well as basic spotting and retouching tools. The tutorial will then continue with a few of the special effects possible with digital imaging, and will also demonstrate some compositing techniques, where two or more images are combined into one. This tutorial was performed in Photoshop, but if you are using a different image editor, you will probably find identical or similar procedures. Most

Step 2: Open File Menu Choice.

image-editing programs have a number of alternate keyboard commands for menu items and tools. Because of the differences in programs, this tutorial uses the menus and tools rather than keyboard commands, but you will work faster if you learn the keyboard shortcuts that your program offers.

1. Acquiring the image. Your image can be from a digital camera or scanned from a traditional print. The image in this tutorial was originally taken as a 35mm slide, which was scanned on a 35mm film scanner.
2. Opening the image. Click on the File menu and select Open. Navigate through the Open File dialogue box until you find your file on disk. Click OK.
3. Saving the file. The file is probably an RGB file, but may be in TIFF, JPEG, or another format. Choose File/Save As . . . to open the Save File dialogue box, and save the file in the format recommended by your image-editing software, for example Photoshop's proprietary file format. If you want to retain the original scan or source file, you should save the file under a different name. As you are working on the file, you should periodically choose File/Save to save your latest changes to disk.
4. Viewing and navigating the image.

a. Screen magnification: Several tools are available for changing the magnification of the image on the screen and for navigating through the image if it is bigger than your monitor screen. When the image is opened, it will normally be displayed so that the entire image is visible on screen. To magnify the image, choose the Zoom tool by clicking on it, then click on the area of the image you wish to magnify. Successive clicks will continue to magnify the image. To reduce the size of the image displayed, hold down a control key (Option on Mac, Alt in Windows) and then click with the Zoom tool. Zooming does not change the file itself, but only your view of the image.

b. Moving through the image: Select the Hand tool (also known as the Pan tool) by clicking on it. You can now click and drag with the mouse button to move through the image. Another method is to use the scroll bars to navigate through the image.

The Image-editing Screen.

5. Straightening and cropping the image. This image is slightly crooked. To straighten, perform the following steps:

a. Select the entire image by choosing Select All from the Select menu on the menu bar. You will see crawling dotted lines around the image indicating that it is selected.

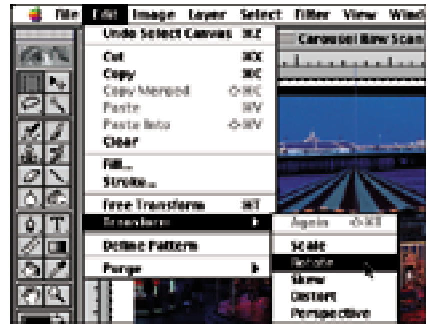
b. Choose Transform/Rotate from the Edit menu. Now the selection box changes to include little squares at its corners and edges. These are called **handles** and can be used to change the image inside the selection box.

c. Move the cursor just outside one of the corner handles and you will see it change to a curved double arrow. This is the rotation symbol. Some image-editing software provides horizontal and vertical guides that you can position for alignment. The blue lines in the image are guides that we have inserted to get the subject matter straight.

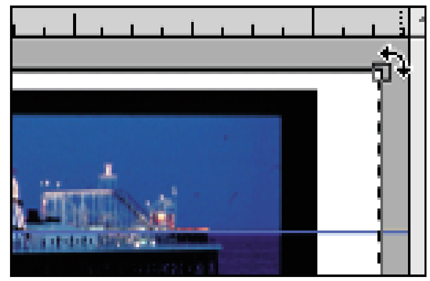
d. Click and drag with the mouse button depressed to rotate the image. In a few seconds the image will redraw in the new position. If it isn't exactly where you want it, move it again. Don't worry about the jaggy lines at this stage. These will clean up when you finalize the rotation. Hit return or double-click inside the selection box to finalize the rotation.

e. The image is now straight, but the borders are crooked, so we will clean these up by cropping the image around the border. Choose the Crop tool from the Tool Box. Click-drag a box approximately where you wish to crop.

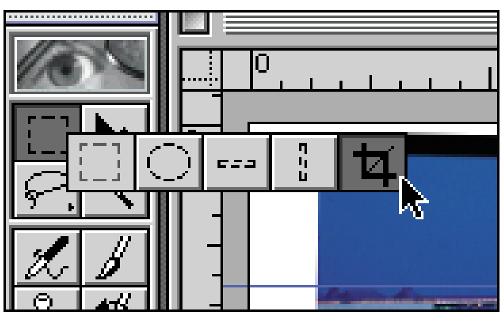
f. The size and position of the crop selection box can now be changed using its handles to reposition corners or sides. You can also click-drag inside the box to move the whole box. When you have the box correctly positioned, hit Return or double-click inside the box to complete the crop.



Step 5.b: Choosing Transform/Rotate from the Menu Bar.

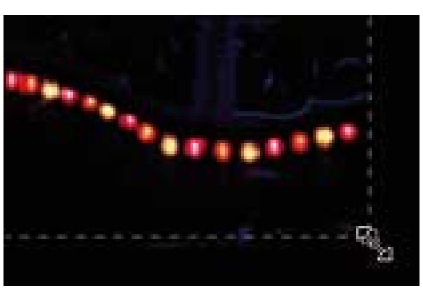


Step 5.c: The Rotation Symbol just Outside the Transform "Handle." The blue line is an alignment guide.

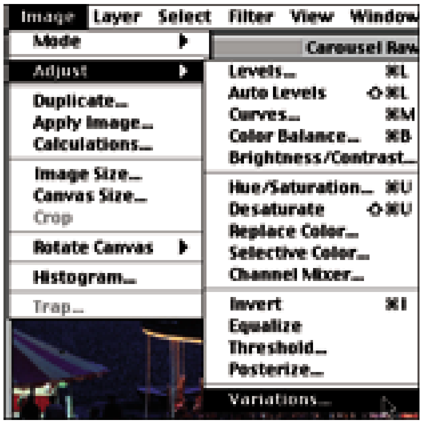


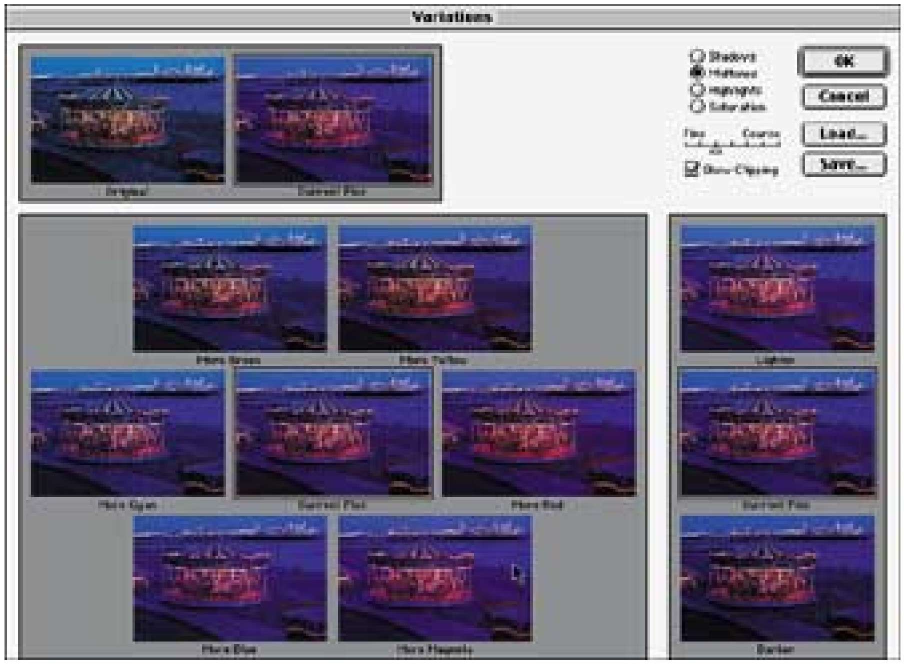
Step 5.e: Selecting the Crop Tool from the Tool Box.

Step 5.e: The Straightened Image with the Crop Selection Box Roughly Positioned.



Step 5.f: Resizing the Crop Selection Box by Click-dragging the Handles.



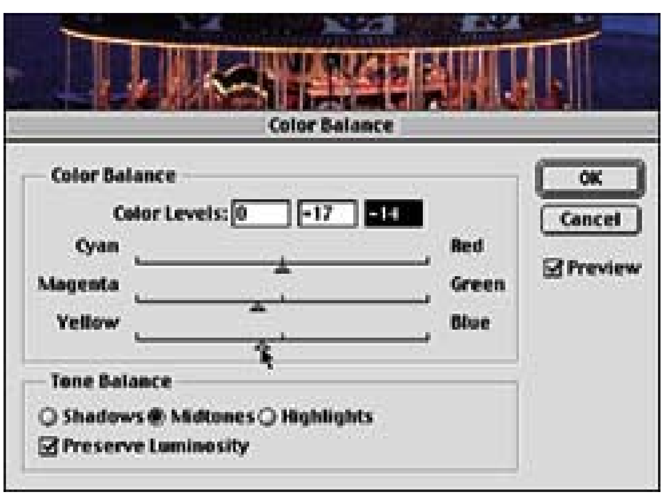


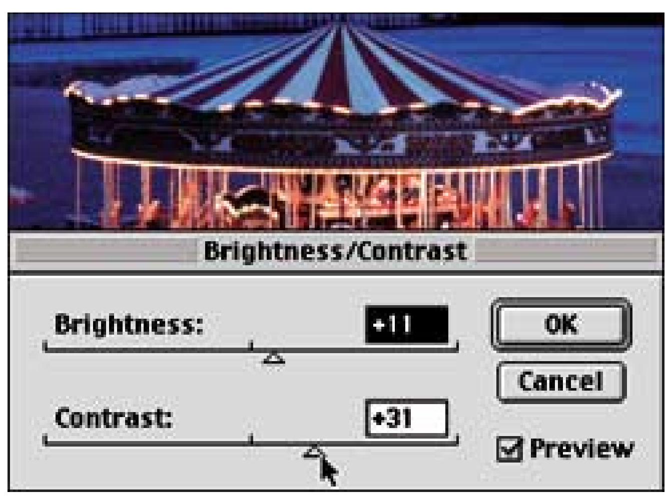
Step 6.a: The Image/Adjust Menu Selection of Tonal and Color Adjustments (above), and the Variations Dialogue Box (right).

6. Overall color and tone correction. In this step we are going to analyze and correct the overall lightness/darkness of the image, its overall color balance, and its overall contrast.

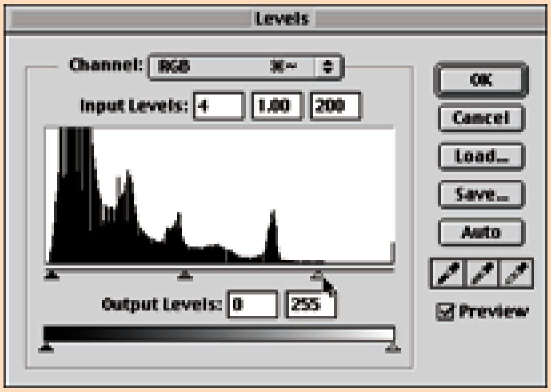
a. First analyze the image to see if there are noticeable image quality flaws. Look at the light values and see if they are convincingly light without losing detail. Look at the dark values and see if they are richly dark without losing detail in important areas. Look at the overall color of the image and see if it has a noticeable color cast toward any one particular color. For those of you who are first learning color correction, Photoshop offers a useful analysis tool called Variations, found under the Image/Adjust menus (see the illustration above). Variations shows you the effect of changing any one of the six additive and subtractive colors. It also shows you lighter and darker images, but does not address contrast. Variations will also perform the correction if you click on the image that you think has improved color,

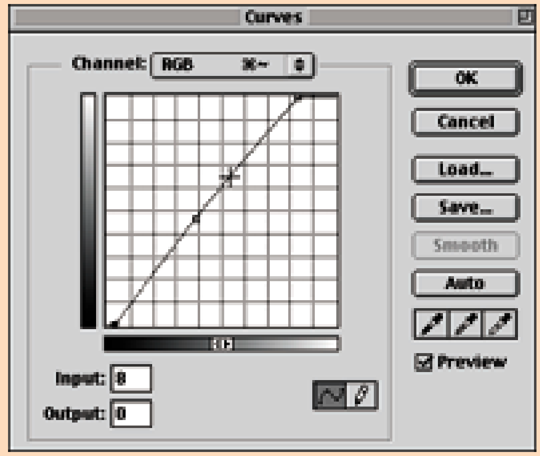
Step 6.b (left): Correcting Color Casts in the Image Using Image/Adjust/Color Balance.
Step 6.c (right): Changing the Brightness and Contrast of the Image using Image/Adjust/Brightness/Contrast.





Levels and Curves





Levels and Curves are more precise methods for adjusting both the tonal values (brightness and contrast) and the color balance of an image. Both Levels and Curves have a Channel menu at the top of the dialogue box that allows you to choose RGB, Red, Green, or Blue. When working in the RGB channel, all colors are affected equally by changes. Individual colors can be changed by selecting their respective channels.

In the Levels box, changes are made by dragging the triangles under the tone graph (called a **histogram**). In this case the highlight slider has been dragged down to give brighter highlights and more contrast.

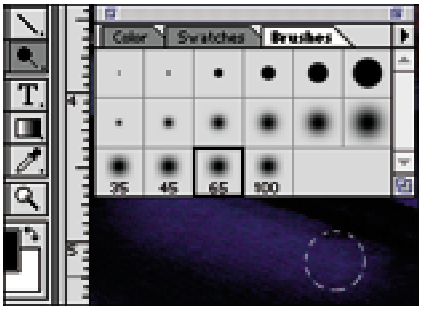
In the Curves box, changes are made by clicking and dragging on the line in the graph to change its shape. In this case, the top (highlight) end point has been dragged to the left, and the bottom (shadow) point to the right to brighten highlights, darken shadows, and increase contrast. Dragging the middle of the curve lightens or darkens midtones. Here the middle of the curve has been dragged up to lighten midtones. ■

and then click OK. However, these color and tonal changes are available as separate tools that offer far more control, so it is better to use Variations only as an analysis tool and click Cancel to exit without making the changes.

b. Once you have determined the corrections you want to make, there are several options for making corrections. These are also found in the Image/Adjust menus. Color Balance gives a lot of flexibility in changing the overall color of the image by way of sliders, boxes, and buttons that choose whether midtones, shadows, or highlights are being altered. Adjust the values until you get the best effect. With Preview on, you can see the changes as you make them.

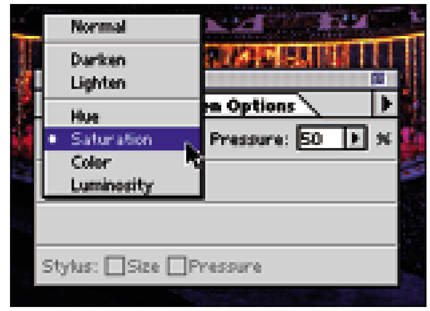
c. To change overall brightness and contrast choose Image/Adjust/Brightness/Contrasts. . . from the menus. This is a simple dialogue box where one slider controls brightness and the other the contrast.

d. Between Color Balance and Brightness/Contrast you can probably get a pleasing overall appearance of the tones and colors in the image. For more precise control, however, advanced users prefer the use of Levels and/or Curves, found on the Image/Adjust menus. See the boxed section for a short introduction to the use of Levels and Curves.



Step 7.a: Lightening an Area Using the Dodge Tool with a 65 Pixel Soft Brush.

The Dodging Tool Has Been Set at 50% Effect in the Options Palette.



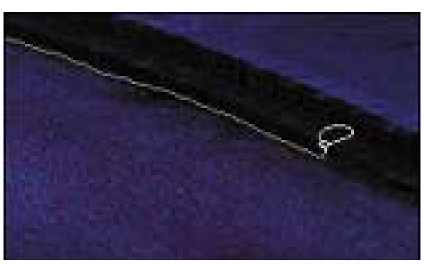
Special Effects Can Be Achieved by Using the Application Mode Menu in the Options Palette

Step 7.b: Selection Tools Available from the Tool Box.

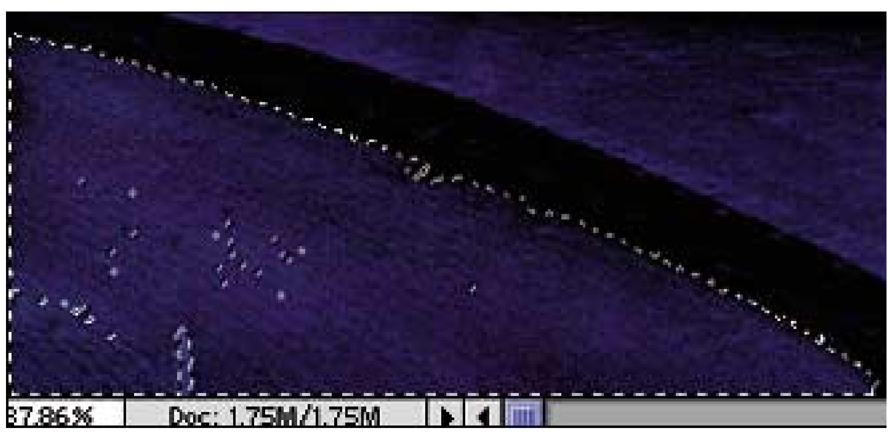
7. Changing local areas. One of the most powerful advantages of digital image editing is the ability to work on specific areas of the image. There are tools that can be used like brushes to make changes in the image. There are also selection tools, which allow you to select specific areas of the image. Only selected areas are then affected by changes.

a. Local tools: Burning, Dodging, Sharpen, Blur. These tools are applied by "brushing" them onto the image by click-dragging with the mouse. The size and hardness of the brush can be selected in the Brush palette. The options for each tool allow you to apply the tool at 100 percent effect, or reduce the percentage so less effect is achieved with each pass of the brush. With options, you can also get special effects from the tool by choosing an application mode.

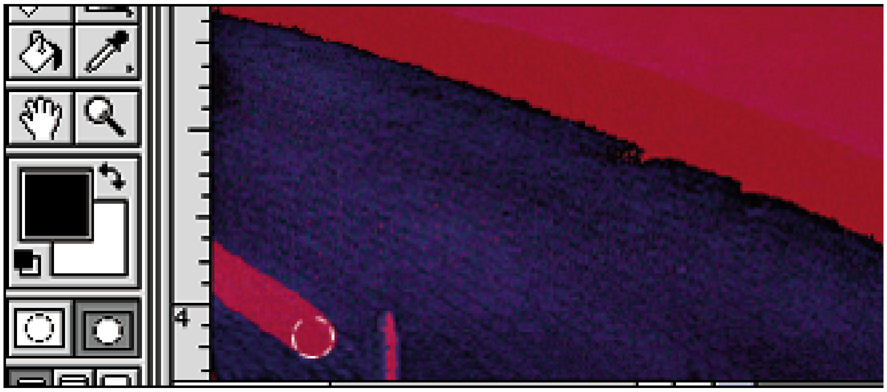
b. Selection tools: There are a number of selection tools available. The Rectangular Marquee tool can be used to drag selections that are rectangular. Hold down the Shift key to make a square. The Oval Marquee cre-



Lasso Tool. Click-drag along the border of the area you wish to select. When you release the mouse button, it will complete the selection with a straight line back to your starting point.



Magic Wand Tool. Clicking once in the area we wished to select produced this result. The white specks inside the area did not get selected. Results with the Magic Wand can be adjusted by changing its tolerance setting in the Options palette.



Quick Mask Mode. Clicking on the Quick Mask icon changes any unselected area to a mask (shown here as red). The mask can be added to by painting on the image with black (which shows as red). You can subtract from the mask by painting in white. Here we are adding to the mask (i.e., subtracting from the selection) by painting with black in the lower left corner. Once you have cleaned up and adjusted the mask, clicking on the Standard Selection icon to the left of the Quick Mask icon returns you to the crawling dashed selection line.

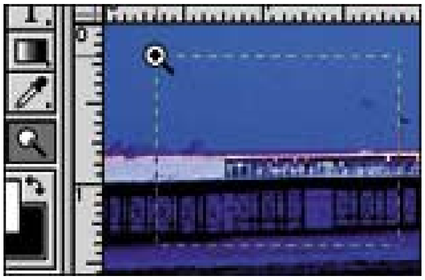
ates oval selections by dragging. Holding the Shift key down while dragging produces circles. The Lasso tool allows you to click-drag with the mouse to draw a selection freehand. The Magic Wand will select any contiguous areas with close to the same tonal values as the spot you click on. The Quick Mask tool allows you to add and subtract from a selection using the brush tools.

c. Feathering the selection: You can soften the edges of the selection so that changes will blend into the surrounding image by “feathering” the selection. Choose Select/Feathers. . ., and the dialogue box shown in the illustration below will appear. Choosing larger feathering values in pixels will cause the selection to be blended into its surroundings over a wider area.

d. When a selection is active, any changes you make, such as painting or correcting tones or color, will only affect the selected area. This gives you control over the appearance of specific areas of the image, which would be difficult or impossible to achieve using traditional darkroom techniques.

Step 7.c: The Select/Feather . . . Dialogue Box.

Step 7.d: Using a Selection to Change a Local Area. Here the Brightness/Contrast menu choice has been used to increase both brightness and contrast of the selected area. Color Balance, Curves, Levels, or any other control can also be used to change the selected area without affecting the remainder of the image.



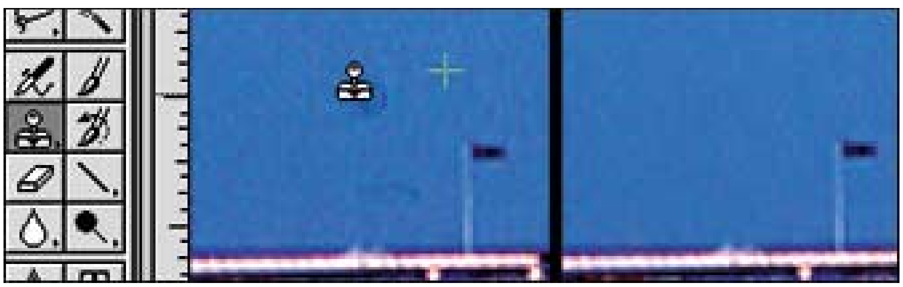
Step 8.a: Zoom In for Cleanup.

8. Cleaning up the image. Another of the outstanding features of digital image editing is its facility at spotting and repairing image flaws, such as dust marks, scratches, and damage. The Rubber Stamp tool (also known as the Cloning tool) is what makes this possible. It picks up part of the image and paints it into another part, at a distance that you define. To clean up your image, perform the following steps:

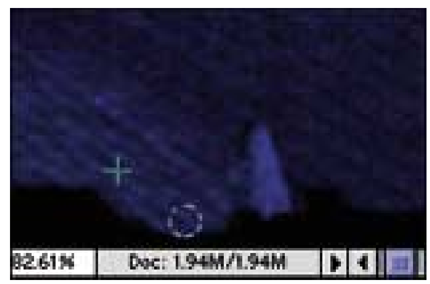
a. Use the Zoom tool to achieve a view magnification that gives a screen image at least two or three times the printed image size.

b. Choose the Rubber Stamp tool from the Tool Box. Show its Option palette by choosing Window/Show Options, and set them for Normal, 100%, Aligned turned on. Hold the Option (or Alt) key down while you click near a defect in an area you wish to copy on top of the defect. Let up on the Option (Alt) key and then click-drag over the defect to "paint" it out.

The Cloning tool can also be used for repairing scratches or damage and replacing missing parts of the image. Cloning is also a useful special effects tool, allowing parts of an image to be copied back into itself or into another image.



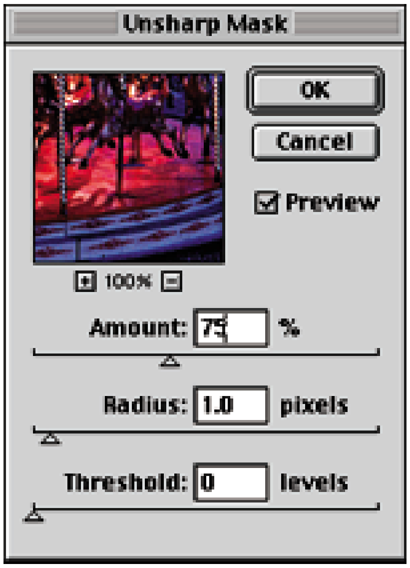
Step 8.c: Cloning Over Defects with the Rubber Stamp Tool. The crosshair is the area the tool is copying from. On the right is the same area after cleaning up with the Rubber Stamp tool.



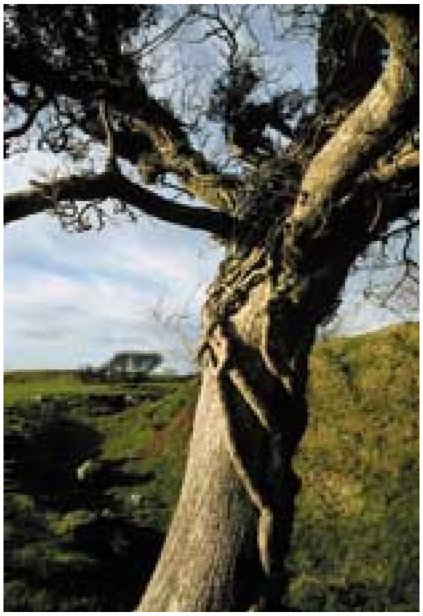
Extending the Image with the Cloning Tool. This area of black at the lower left of the image was left in the rotation step. The Rubber Stamp tool is used to copy image information into the black area.

9. Overall sharpness corrections. Sharpening is a procedure unique to computer image editing. By increasing the contrast between edges in the image, sharpening is able to make the image look more in focus. Care must be taken when sharpening not to overdo it, since the result may be a harsh unrealistic look, with the creation of **artifacts** (undesirable pixels not part of the original image). There are several sharpening methods in use, but the most controllable is Unsharp Masking. In spite of its contradictory-sounding name, Unsharp Masking increases the sharpness of an image. To judge the effect of sharpening, use the Zoom tool to change the view magnification so that the screen image is slightly larger than the print of it will be. For maximum screen sharpness, use view magnifications in ratios of two with 100% (e.g., 25%, 50%, 100%, 200%, etc.). Choose Filter/Sharpen/Unsharp Mask from the menu. Experiment with the settings in the Unsharp Mask dialogue box until you get a result that is acceptable. After you have sharpened, it is a good idea to recheck the clean-up of the image.

Step 9: Sharpening Using Unsharp Mask. The left image is the sharpness of the raw scan. The right image is with Unsharp Mask set for the values in the dialogue box shown to the far right.

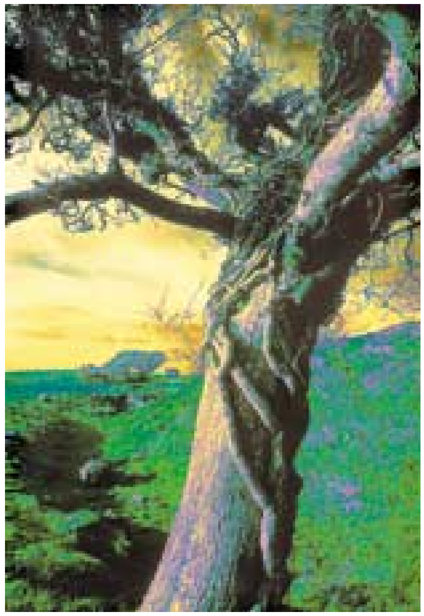


The Finished Photograph. In addition to the steps in this tutorial, many other corrections and enhancements have been performed on this image. Hue and saturation of the yellow/orange lights were increased. The sky was selected and color corrected separately, and so on.



Special Effect Using Image Editing Software. This is the original unmanipulated image.

© Bruce Warren.

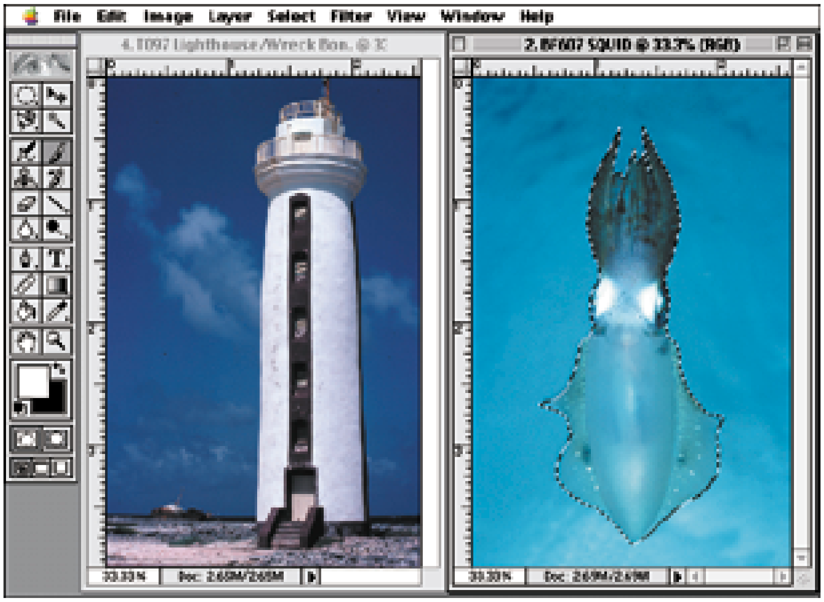


Here the image color and tone were radically changed by using Curves and dragging each of the channel curves into distorted shapes.

Radial Blur was chosen from the Filters menu, and set for the spin effect.

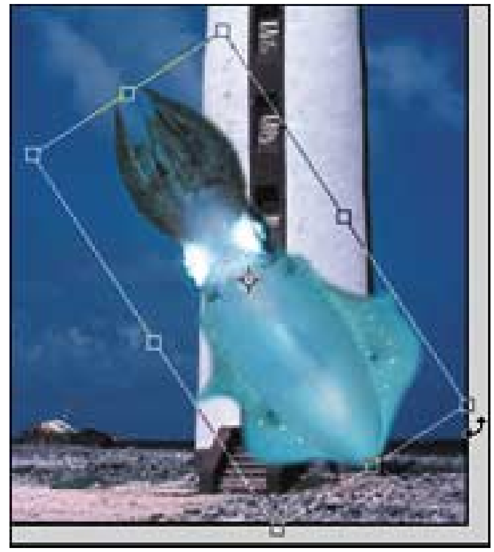
Special Effects

Digital image-editing software contains a myriad of techniques for radically altering the straight photographic image. These range from effects that mimic traditional special effects, such as sabattier, posterization, high contrast, hand painting, blur, and others, to wild effects that are only possible using the computer. Some special effects can be achieved by manipulating the controls on the Image/Adjust menu, such as curves. Others are listed on the Filter menu, and consist of routines for altering the image by distortion, mimicking artwork, adding noise, and so on. Some of these filters come with the image editor, but there are also hundreds of special effects filters available from third-party software companies. These may operate as a **plug-in** to your image-editing software, meaning that they can be accessed from within your program.



Simple Composite. On the left, we see both images open and displayed side-by-side. The squid has been selected using the Lasso and Quick Mask tools, and feathered to help it to blend with its new environment. To move it to the other image, choose Edit/Copy, then activate the lighthouse image by clicking on it and choose Edit/Paste. Some programs will allow you to simply click-drag the selection from one window to the other.

Images © Bruce Warren.



Positioning and Sizing. In Photoshop, the squid is automatically pasted in as a new layer. Choose Edit/Free Transform, and the imported object will be enclosed in a box with handles with which you can resize, stretch, move, and rotate the object until you get it where you want it. Hit Return to finalize the transform.

Combining Images (Composites)

Another of the strengths of digital image editing on the computer is the ease with which images can be combined with each other (composited). What required laborious multiple exposure, multiple printing, collage, or montage techniques with traditional photographic materials can be accomplished easily with the selection tools and Cut and Paste commands.

Outputting Digital Images

Viewing a digital photographic image on a computer monitor may be a widely used method, but quality output of digital images requires that they be printed to film or paper. Photographs on paper or film are also easily viewed under a variety of conditions, and do not require a computer and monitor. The possibilities for outputting digital photographs are outlined here, along with some suggestions for improving your print output.

Output Methods

There are two basic categories of digital image output: (1) printing the image on paper; and (2) printing the image to photographic film. A wide variety of equipment and materials are available, and your choices can heavily affect the resultant quality. The possible routes for printing digital photographs on paper include **computer printers,** offset printing presses, and **digital enlargers.** Digital photographs are printed to film with a device called a **film recorder.**

Computer Printer.

Computer Printers Computer printers are available in several types, but the most common are inkjet and electrostatic (usually called laserjets).

Inkjet printers spray dots of ink on paper and are very suitable for printing photographs. Their advantages include good image quality and color reproduction and moderate prices. Their disadvantages include high cost per page for materials (ink and special papers) and poor print durability and longevity, although new inks and papers are rapidly improving both durability and print life. Some service bureaus offer Iris inkjet printing, which is a superior method of printing with inks. Longer-life inks are available for the Iris printer, so the longevity of Iris inkjet prints can match or exceed some traditional color print materials. However, inks for the Iris printer, like those of consumer inkjet printers, are very susceptible to water damage. The Iris printer has the advantage of being able to print on almost any stable, flexible medium, and many photographers have their photographs printed by the Iris process on heavy, high-quality water-color papers, as well as other more exotic papers.

Electrostatic (laserjet) printers use a technology similar to that of photocopiers. They do not give very good photographic quality and are relatively expensive, especially for color. Their advantages are speed and low cost per page for materials.

Dye sublimation printers give the best photographic quality for computer printers, but are expensive to purchase and have a high cost per print for materials. Many service bureaus can make dye sublimation prints for you from your digital files.

Offset Printing Offset printing presses use half-tone techniques to print photographs on paper with permanent inks. To reproduce your photographs in this way, you will have to work with a printing firm. See pages 498–502 for more information on having your photographs printed.

Digital Enlargers Digital enlargers currently supply the highest reproduction quality photographic prints in large sizes, by printing digital files directly to traditional photographic papers. The LightJet 5000, for example, uses red, green, and blue laser beams to expose the paper directly in print sizes up to 50 inches square. These machines are very expensive and require processing facilities for traditional print materials. They can print on any light-sensitive paper that can pass through their roller system, such as type-C materials and Ilfochrome. A very few labs have been successful at printing black-and-white RC papers in digital enlargers. A number of service bureaus offer prints from digital enlargers.

Film Recorders Film recorders expose film to the photographic image directly from the digital file. Older types of film recorders contain a high-quality cathode-ray tube (CRT) monitor, which is photographed onto film via an optical system. Newer film recorders use laser beams, much like digital enlargers, to directly expose the film and provide much sharper, cleaner results. Film recorders can produce images on positive or negative films up to 4 × 5 inches or larger depending on the capacity of the recorder. These are expensive machines and require traditional film-developing facilities. Service bureaus can supply you with film recorder output from your digital files.

Techniques for Successful Printing

If you are printing on your own computer printer, for example an inkjet printer, you can improve the quality of your printing output by the choices you make in materials, by testing your equipment and materials, and by the image corrections that you perform with your image-editing software.

The *printer medium* (paper) that you choose is perhaps the single most important factor in getting quality output from your printer. Most printer manufacturers market printer media under their brand names, and generally these work well with the same brand printer. You can certainly use other brands of paper in your printer, but you may have to experiment with the printer software settings and run a number of tests to determine the best settings for each paper. Several photographic paper manufacturers are now marketing inkjet papers (e.g., Kodak, Fuji, and Konica), and these have the look, surface, and weight of traditional photographic papers. Of course, the finer the paper, the more it costs.

Testing and calibration of your monitor and printer are other ways to ensure predictable quality output. To calibrate your monitor, use a calibration utility such as Adobe Gamma, or the monitor calibration utility supplied by your operating system. For testing your printer, choose a digital image with a wide range of colors and tones as a test image. You may find that your image-editing software includes a test image for printing. In addition to a photographic image, most test files also incorporate color patches and grayscale step wedges to help you determine the accuracy of your printer's color reproduction. Print out the test file, and compare the results to your monitor. The printer software controls for good printers will allow you to introduce corrections for any differences you see.

The testing that you do for your own printer will probably not apply to images that you deliver to a service bureau for output. Talk to the service bureau about controlling the quality and color of the output. The bureau may be using a color management system, such as ColorSync, and can give you profile files to make color more predictable.

Color and tonal corrections can be made with your image-editing software once you have tested and standardized your system for the output you plan, using your monitor as a fairly accurate guide to what the print output will look like. No matter how much testing and calibration you do, the monitor image will never look exactly like the printed piece, but with practice you can learn to predict results with reasonable accuracy.

Sample Computer Printer Tests.

Electronic Distribution of Digital Images

One great advantage to digital photographs is that they can be transported easily in electronic form. You can record images on storage media, like magnetic or optical disks, and send them to others to view on their computer. You can also send and receive digital images over phone lines or via satellite using modems. If you wish to distribute your photographs electronically, the easiest ways are to put them on magnetic or CD-ROM disks or to make them available on the World Wide Web by placing them on a Web site.

Image Disks

CD-ROM Image Disk.

Placing photographs on CD-ROM or magnetic disks is becoming an increasingly cheaper method of distributing images. Many film processing companies can put your images on disk for you, and some include a software viewer on the disk, which lets people view the images as a slide show. It is also possible to put sound and video clips on the disks, but of course the price goes up as you make the disk more complicated. This is the basis of multimedia disks, which contain images, text, sound, and are usually interactive, allowing the viewer to navigate through the contents of the disk by clicking on menu choices or graphic "buttons."

An alternative is to publish your own disks. Freeware or inexpensive shareware programs (such as QuickShow) can be included on the disk for viewing ease. Check the licensing requirements of the software to be sure that it is legal for you to include it on your disks. The disks can be magnetic, but CD-ROM is a popular choice for distributing images. You can make your own CD-ROMs by purchasing a CD recorder. These are currently reasonable in price and record on very inexpensive media. The recordable CDs are not as permanent as the professionally produced CDs, however, so if you are looking for a more permanent medium, you may want to have a CD master disk pressed by a service bureau. Permanent copies can then be produced from the master in larger quantities. One nice thing about CD-ROM disks is that they can be produced with cross-platform readability, so that your images can be viewed on either IBM-PC or Macintosh computers.

The file format you use is determined by the viewing software that you place on your disk. To conserve disk space and make image viewing quicker, small file sizes are usually desirable. These can be achieved by reducing the resolution of the image to screen resolution (e.g., 72 pixels per inch), and by using compression, such as JPEG. Be sure to include your copyright on the disk and images (see the section on Copyright Law and Digital Imaging later in this chapter).

Web browser interface.

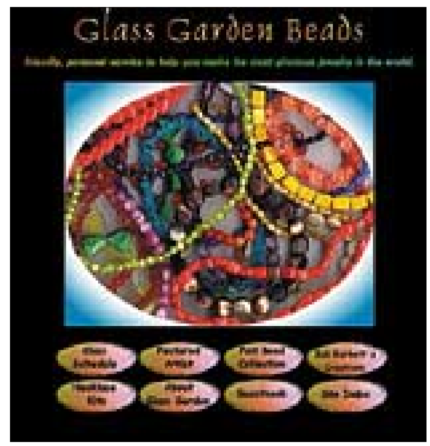
Image courtesy of Netscape 6.

Using the World Wide Web

The **World Wide Web** (also known as the **Internet**) has blossomed almost overnight into an amazing vehicle for communication and distribution of information, including images. To quote Deke McClelland: "The Internet may well be the most chaotic, anarchic force ever unleashed on the planet. It has no boundaries, it has no unifying purpose, it is controlled by no one, and it is owned by everyone. It's also incomprehensibly enormous, larger than any single government or business entity on the planet . . . In terms of pure size and volume, the Web makes the great thoroughfares of the Roman empire look like a paper boy's route." In other words, what a great opportunity both to see other photographers' work and to make your own available for viewing.

Access to the Internet To get on the Internet, you will need some equipment and services. You will need a computer with a reasonably fast modem to attach to your phone line. Get the fastest modem you can afford, since it makes Web surfing much faster and more enjoyable. You will also need an **Internet service provider.** These are springing up all over, and have many payment plans depending on the number of hours you spend on the Web. They range from international giants like America Online to local services, any of which give you complete access to the World Wide Web, but which may have varying services, features, and speed of access. You will also need an Internet browser, which is the software that allows you to navigate on the Web. The current most popular browsers are Netscape Communicator and Microsoft Explorer. Your Internet service provider usually supplies you with a browser, and you can also **download** (copy to your computer) other browsers from the Web.

The Internet is organized into **Web sites,** which individuals or corporations set up so that they can be contacted via the Web browser. Each site has an address, and you can access the site by typing in the address in your browser. The Web is a remarkable resource for researching photographic topics.



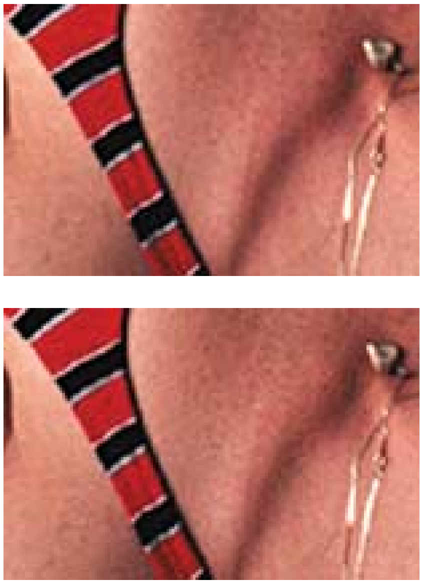
Sample Web Page Design.

Setting Up Your Own Web Site You can set up your own Web site so that others can find and look at your photographs via the Web. Some Internet service providers provide personal Web sites (sometimes called Web pages) to their customers. Your Web site consists of files that you can design to contain text, graphics, and images. You can have an opening screen (called the **home page**), which tells what your Web site is about, and on that screen you can have graphic "buttons" or highlighted text (known as **links**), which when clicked on, bring other files to the screen, or allow jumps within the same file to different sections. These links can even take the viewer to other Web sites. For example, you could have an opening screen with a "contact sheet" of your images. When the viewer clicks on any image, it could open a full-screen version of the image. Other links could provide a page with biographical detail or connect the viewer to another related Web site.

You need software such as Adobe PageMill or Microsoft Front Page to design the files for your Web site. Some word processors also include the capability of producing documents for use on the Web.

Preparing Photographs for the Web It takes time to send data over the Web, so it is important that you keep your image file sizes as small as possible. In preparing image files for the Web, you are trying to achieve a balance between the size of the file (for speedier transmission) and the quality of the image that the viewer sees on his or her monitor. The following guidelines will help you to make that balance work.

Size of the images is determined by the pixel dimensions of the image, not its size in inches or its resolution, since that is how the receiving computer monitor displays them. An image of about 400 pixels high by 600 pixels wide will fill all or a good percentage of most monitors, so size your images in pixels, according to how much of the screen you want them to occupy. You should start with an image that is at least 400 × 600 pixels in size so that you can then resize it to the desired number of pixels using your image-editing software.



Comparison of 24-bit Color and 8-bit Indexed Color as Seen on a Computer Monitor. These are life-size sections of images displayed on the monitor at 100% (i.e. pixel for pixel) maginification. The millions of colors possible with 24-bit color (top) provide smoother tones, especially in the skin. Reducing the number of colors to 256 in the 8-bit indexed color image (bottom) produces coarser tonal gradations and the appearance of slightly more contrast.

Color mode of the images should be 24-bit RGB initially for the first steps of image editing, color correction, and sizing. When you adjust the color and tones in the image, keep in mind that the appearance at the viewer's end will depend on his or her monitor. If you are working on a Macintosh you will see the images brighter than someone viewing the same file on an IBM-PC. Since the highest percentage of viewers on the Web are using IBM-PC compatible computers, you may want to keep in mind that the images will be darker on their machines than on your Macintosh. Many older computers may have 8-bit monitors, rather than the 24-bit monitors most computers come with today. That means the monitor can only display 256 colors, which will reduce the reproduction quality markedly.

Once you have made the initial color and tone corrections to the file, you may want to change its color mode to indexed color to reduce the size of the file. Changing to indexed color also reduces the quality of the image. An 8-bit indexed color image has only 256 colors for display, but takes up about one-third the file size. Image-editing software will allow you to change the bit-depth of the image when you change to indexed color, so you could choose fewer colors as well. A 5-bit indexed color image shows only 32 colors.

Choosing the file type in which to save your images depends again on the balance between size and quality. The two image file types most widely used on the Web are JPEG and GIF. JPEG provides compression, and will work with 24-bit images to produce smaller files. Since JPEG is a "lossy" compression, the choice you make of JPEG image quality affects not only the file size but also the image quality seen after decompression. Experiment with different quality levels when saving as a JPEG to see what is acceptable to you. You will probably not want to use JPEG quality lower than medium. GIF files provide compression which is lossless, but work only with indexed color files of 8 bits or fewer.

Your choice of whether to use JPEG or GIF needs to take into account the color nature of the photograph you are sending, as well as the viewer that it is reaching. If your viewer is working with an 8-bit monitor, sending 24-bit JPEG files is wasted, since they won't see the 16 million available colors anyway. In that case the GIF file may give even higher viewing quality than the JPEG. On the other hand, if your viewers are working with 24-bit monitors and you want them to see the images at the maximum number of colors, you should send them as 24-bit RGB JPEG files and use the higher levels of JPEG quality. If you have graphics or images that contain few distinct colors and no gradations between colors, you may be better off converting them to indexed color and saving them in GIF file format. They will then display faster, and will probably appear at higher color quality level on the viewer's screen.

In any case, you should always save the original 24-bit RGB full-size color image as a master file before doing any conversions to JPEG or GIF. That way you can always return to the master file (which contains all the original data) if you change your mind about size, compression, or indexed color choices.

Ethics and the Law in Digital Imaging

Photographers and users of photography have always had a number of ethical and legal issues with which they must deal. The primary ones are the issue of copyright, which governs the ownership and usage of creative materials, and the issues of accuracy and honesty in reporting events by photographic means. The advent of digital imaging has not really changed these overriding concerns. What it has done is to make it easier to violate the legal and ethical guidelines that have been adopted over the years.

Truth and Photography

Accurate and honest reportage with the camera has always been problematic. The adage that "a photograph never lies" has been proven false many times. Photographers and picture editors have used a myriad of techniques to mislead the viewer of a photograph. Taking a subject out of context by careful framing or cropping, for example, is a simple way of giving the wrong impression of a person or event. Choice of lighting or camera angle, or the capture of a fleeting expression, are other ways of influencing viewers' responses away from a truthful rendering of the situation. Photographers have posed their subjects to give misleading impressions. Even from the early days of photography, some enterprising propagandists have found that outright manipulation of the photographs by cutting and pasting, rephotographing, retouching, or multiple printing techniques could present a completely false view of reality. Digital image editing makes this manipulation process not only easier, but virtually undetectable in published photographs.

While people may readily accept manipulation of photographs in fine art photography or in advertising, they place the photojournalist under stricter ethical expectations. When the *National Geographic* digitally moved the pyramids of Giza so that the photograph would better fit on its vertically formatted cover, many readers were outraged by what they considered to be an untruthful rendering of the subject in a magazine long considered a bastion of honest reportage. The discussions of what are the limits of acceptable manipulation or retouching in photojournalism or documentary photography are still lively. Many feel that any manipulation at all, even the removal of distracting unrelated background from a photograph, is not allowable for truthful reportage. The important thing is to be aware of the ethical abuses possible with digital imaging, and to tread carefully in areas where the viewer is expecting an honest representation of the subject.

Bending Reality in an Advertising Photograph. Zach Burris. In this catalog cover photograph, image-editing software was used to make summer clothing look like a frozen treat. © Lands' End. Inc.

Copyright Law and Digital Imaging

The fact that an image is digital in nature does not change its protection under the copyright law. The creator of the image holds the copyright unless she or he releases those rights by contract or the image was created as **work for hire.** The problem with digital imaging is the ease with which it allows images to be copied and recopied with no loss of quality. The mass distribution of images electronically has also had a misleading effect on the attitudes of some users of photographs. Some of the distributed photographs are "royalty free," which means they can be reproduced without payment to the copyright holder. Others are purchased on disks or over the Web as a group of photographs called **clip art**, which means that they can be used within the guidelines of the license without further payment. With the proliferation of this means of marketing photographs, some individuals begin to feel that anything that is on the Web or on disk is fair

For more on copyright law, see pages 517–18.

game for usage. That is definitely not the case, and active photographers are pursuing legal means to recover damages for improper usage of their images. A recent case involving photographers Carl and Anne Purcell, for example, involved the use of a large number of their images on the Web by America Online. The court ruled in favor of the Purcells, with an undisclosed settlement.

A few inaccurate ideas that are used as justification for "borrowing" other artists' copyrighted work are floating around. Some believe that as long as the borrowed art doesn't exceed 10 percent of the final work, that it is all right to use it without permission. Another misconception is that altering the color or distorting the image in some way releases users from the necessity of getting permissions. The fact is that any identifiable use of another's work is governed by the copyright law.

A related issue to copyright infringement is the illegal use of software. Software is copyrighted and cannot be copied or used without the express consent of the owner of the copyright. Many individuals who would not dream of shoplifting a $500 leather jacket will illegally copy a $500 computer program without a qualm.

Music is also copyrighted, so if you plan to publish multimedia disks containing music, be sure to get the necessary permissions. It is especially important for those in the creative fields who would like their own copyrights to be respected to show that same respect to other copyright holders. Users of photographs should keep copyright in mind both for ethical reasons and to protect themselves from litigation.

READING LIST

The literature for computer-related fields like digital imaging changes so rapidly, that any list may soon be out of date. Start with the suggestions below if they are still current and available, but for a more current reading list dealing with digital photography, consult your local library or search the Internet.

Adobe Creative Team. *Adobe Photoshop 5.5 Classroom in a Book*. San Jose, Calif.: Adobe Press, 1999.

Bouton, Gary David, Gary Kubicek, and Barbara Mancuso Bouton. *Inside Adobe Photoshop 5.5.* Indianapolis, Ind.: New Riders Publishing, 2000.

Dayton, Linnea, and Jack Davis. *The Photoshop 5.0/5.5 Wow! Book.* Berkeley, Calif.: Peachpit Press, 1999.

Dinucci, Darcy, Maria Giudice, and Lynne Stiles. *Elements of Web Design*. Berkeley, Calif.: Peachpit Press, 1998.

Haynes, Barry, and Wendy Crumpler. *Photoshop 5 & 5.5 Artistry.* Indianapolis, Ind.: New Riders Publishing, 2000.

McClelland, Deke, and Ted Padova. *Macworld*® Photoshop® 5 Bible. Foster City, Calif.: IDG Books Worldwide, 1998.

Pogue, David. *Macs for Dummies*, 6th ed. Foster City, Calif.: IDG Books Worldwide, 1998.

Rathbone, Andy. *Windows 98 for Dummies.* Foster City, Calif.: IDG Books Worldwide, 1998.

Stanley, Robert. *The Complete Idiot's Guide to Photoshop 5.* Que Education & Training, 1998.

Weinmann, Elaine, and Peter Lourekas. *Photoshop 5.5 for Windows and Macintosh (Visual Quickstart Guide Series).* Berkeley, Calif.: Peachpit Press, 1999.