DIGITAL IMAGING BASICS
by Robert Berdan updated Jan 1, 2004

Digital images are widely used in web pages, multimedia presentations and for making "quick" prints. Digital imaging started in the space industry and was then applied to medical imaging. Today, digital imaging is widely used on the Internet, in Newspapers and for creative advertising. The sale of digital cameras is expected to overtake the sales of regular cameras very soon.

There are a variety of ways to digitize images - which one you use depends on: what you can afford pay, what you need to do with the image, and what hardware and software you own or plan to purchase. Digitizing is the process of converting an image into 1's and 0's called bits that a computer can understand.

Common methods of digitizing an image are:

1) Kodak Photo CD made from slides or negatives Cost $2.50\slide
2) Flatbed or hand scanner - Scanner Cost $250 - $1500
3) Slide scanner - Cost between $1000 - $2,500
4) Digital Camera - Cost $150 to $25,000
5) Video camera - $600 and up, requires a frame grabber $600

PHOTO CD

The most economical way to digitize your images is to have them placed onto a Kodak Photo CD. Most major camera stores offer this service at a cost of about $2.50\slide. You can place up to 100 images on a CD and they are digitized at 5 different resolutions. To view and edit these images on your computer you will need a CD player with Kodak Photo access software or other image editor like Adobe PhotoDeluxe, Adobe Photoshop, or Paintshop Pro. Image editing software is required to manipulate the images, re-size them and save them in other file formats such as JPEG or GIF. Image editing requires that your computer have plenty of RAM (random access memory, 16 MB is the bare minimum). Images placed onto photo CD are compressed with the largest images being 24 MB (There is a Pro CD format that offers a 72 MB size image as well). For most purposes file sizes between 1 to 4 MB are sufficient to output to an ink jet printer or 35 mm film recorder. To edit images you usually need 4-5 X the amount of RAM as the image file e.g. to edit a 2 MB file you need about 10 MB of RAM.

SCANNERS

Optical resolution and software interpolation.
Economical flat bed scanners have optical resolutions ranging from 300 - 1200 dpi (dots per inch). Many scanners can increase their true scanning resolution by a process called interpolation. Interpolation is a software based process than can enhance resolution form 300-400 dpi up to 1200 x 1200 dpi. To achieve this increase, a program inserts pixels into the image to increase the apparent resolution. The process works well for line drawings but not for photographs. The resolution you scan an image depends on what you wish to do with the image and the method of output. Images for multimedia presentations and the World Wide Web should be scanned in at a resolution at least as much as your computer monitor (IBM PC 96 pixels\inch ppi, for Macintosh 72 ppi). Note the difference in monitor sizes between Mac's and IBM PC's means images created on a Mac will be about 15% smaller when viewed on an IBM PC. As the cost of some flatbed scanners has fallen to $300 and less, hand scanners have largely disappeared. When buying a scanner, the greater the bit depth, the greater the number of colors the scanner can capture. Canon makes a 42 bit scanner for $199 that is excellent. Other companies that make excellent scanners include: Epson, Hewlet Packard, and Microtek.

Slide scanners have optical resolutions ranging from 600 dpi - 4000 dpi. To produce a high quality 8 x 10 photograph for the cover of a magazine you need a scanner capable of digitizing the image at 2800 dpi or higher. They can scan images for color slides, color negatives and black & white negatives. More expensive slide scanners can accept film formats larger than 35 mm but cost several thousand dollars. Minolta, Olympus, Polaroid and Nikon make economical slide scanners. Professional digital labs usually use drum scanners for scanning slides. These scanners cost $20,000 and up but provide a greater dynamic range, hence better reproduction. Such high quality is rarely need for multimedia or web based projects. An important feature of the best slide scanners is that they have a dynamic range of 3.6 or greater. The dynamic range is a measure of the difference between the brightest and darkest part of an image. Slide film, like Fuji Velvia captures a dynamic range of 3.6. If you wish to capture all the information on the slide your scanner must have at least this range. Minolta and Nikon have introduced desktop scanners

that capture images with a dynamic range of 3.6 and are excellent for making digital prints. Other factors that will increase quality is the ability to scan the images multiple times. This features reduces "blue noise" apparent in the shadow regions of images. The Nikon LS-2000 scans the slide up to 16X and removes virtually all the noise from shadow regions. Expect slide scanners to get better and cheaper.

VIDEO CAMERAS

Video cameras are "digital cameras". Both video cameras and single frame digital cameras record images using a CCD (charged coupled device). The larger the size of the CCD and the greater number of pixels it contains, the higher the resolution of the image. It is possible to input video images directly to a computer equipped with a video frame grabber. Some Macintosh computers come with AV or audio visual input boards that can "grab" single images from video tape. Video balls are available for under $300 that can be used to capture single low resolution images. The quality of the image depends on the quality of the video camera and its CCD and the type of digitizing board you put in your computer. High quality digitizing boards are available for professional video editing, but are expensive. Economical frame grabbers are usually not good enough for developing multimedia or web based projects.

DIGITAL CAMERAS

Digital cameras at an economical price have been available for a few nears now. Olympus, Sony, Kodak, Apple, Nikon and Casio are common name brands. Most major news papers have been using digital cameras for years, but these cameras cost between $7,000 - $25,000. The new smaller digital cameras for consumers produce medium resolution images (640 x 480 pixels or less) and few provide high quality images (e.g. 1024 x 768) suitable for making color prints, multimedia and the WWW. Digital images in general are not as good as images produced on film in a regular camera. The main advantage a digital camera offers is speed, the image is available immediately and can be sent over a phone line or network. Older digital cameras used to "eat batteries" and were notoriously slow to save the images. Today, most digital cameras use rechargeable nickle metal hydride batteries which hold out for hours even at -20! Also, most cameras now come with some sort of digital film - compact flash or smart media cards. Both are excellent in my experience, but they are still very expensive with a 96 MB card costing several hundred dollars. The number of images you can store depends on the file size and quality you save your images.

CHOOSING A COMPUTER FOR DIGITAL IMAGING AND DESIGN

A question I get asked frequently is what type of computer should I buy if I want to get started in digital imaging, or web design. The next question is which computer is better - Mac or an IBM clone. Here are my recommendations.

Look for a computer with the following features.

1 256 MB of RAM or greater - the more the better (1 GB is good)
2. 60 Gigabyte or larger hard drive - the larger the better
3. A computer that supports 24 bit (16.7 million colors) for photo editing
4. A CD ROM, CD ROM writer and or a DVD player
5. Purchase a high quality monitor, 17 inches or larger, analog monitors are better for photo editing than LCD - LCDs are better for viewing text

Mac or IBM PC - both are good and it is largely a matter of personal preference. IBM PC clones are cheaper, and more widely available. There is also more software available for the PC than the Mac. I used to prefer working on my Mac, but most of my clients are on IBM PC clones and the latest software seems to come out on PC first. UNIX based machines are fast, very expensive and software costs are extremely high- they are great if you can afford one.

ADD these accessories as your budget allows

1. High speed modem - cable or DSL modem
2. Internet Account ($200-$1000)\year depending on features
3. Iomega Zip Drive 100 MB or 250 MB ($200)
4. Color Printer ($100) Epson Photo Stylus or HP for color prints
5. Flatbed scanner ($150)

Essential SoftWare

1. Adobe Potoshop or Photoshop Elements
2. HTML editor: notepad, Frontpage, Dreamweaver, Go Live
3. Netscape or MS Explorer - web browser version 6.0 or greater
4. Flash 5.0 for animation

COLOR PRINTERS

Two outstanding photographic quality printers that became available in June of 1997 for under $1000 are the Epson Photostylus and the Hewlet Packard DeskJet 890Cse. The Epson printers attach to both IBM PCs and Macs. The HP printer must be purchased for one configuration or the other. Both printers produce outstanding photo quality images on special paper. Most inkjet prints will only last a few years before color fading becomes apparent. Epson, HP, Kodak and Cannon all make excellent photo quality printers. The Epson 820 for $110 is incredible, but they get you on the ink cartridges!

DIGITAL FILM RECORDERS

If you wish to output your digital images to film a digital film recorder is required. Film recorders are expensive starting around $5,000. Most digital service bureaus have a film recorder. Science & Art Multimedia charges $5.00\35 mm slide, Vicom Multimedia charges $8.00\35 mm slide and Photo Decor charges up to $75 for a 4 x 5 inch slide. PhotoDecor in Calgary uses a $250,000 film recorder and can produce a "second generation negative" that looks as good as the original. I would not recommend purchasing a film recorder unless you plan to become a service bureau. If you do purchase a film recorder, look for one with 8,000 lines of resolution or greater.

DIGITAL IMAGE FILE FORMATS

Once an image is "digitized", the image can be stored onto a hard disk, floppy disk, CD ROM or other device. How an image is stored affects the file size, image quality and the type of computer and software programs that can read or open the file. There are many different file types, but they can be grouped into 3 major types:

Raster images (bitmaps)
Vector images (determined mathematically drawing packages)
Metafiles (combination of bitmap and vector)
Raster images consist of thousands of dots, called pixels, that are arranged in rectangle called a "bitmap". Raster images are created by scanners or paint programs. All faxes are composed of raster images. TIFF, JPEG and GIF images are raster images.

Vector images are based on mathematical formulas and are produced using CAD (computer aided drawing) , drawing, and charting software programs. This file type can be scaled up in size without any loss in quality. Lines remain smooth even when enlarged because they are determined by mathematical equations. In contrast, a raster image begins to show "steps" when enlarged and an overall loss in quality. Vector based file types include: DXF, EPS, DRW, AI, PICT.

Metafiles contain both raster and vector components and are used by some drawing and charting programs e.g. Microsoft PowerPoint. Some examples of metafiles are CGM and MET.

It is possible to convert some file types into others:

a vector file can be converted into another vector file typ
a vector file can be converted into a raster file
a raster file can be converted into a another raster forma
a raster file can not be converted "directly" into a vector file format*
* raster images can be converted into a vector format indirectly using an auto trace program (e.g. Adobe Streamline)

THE MOST COMMON IMAGE FILE TYPES

TIFF - tagged image file format is one of the most common raster file types. TIFF files are readable on both Macintosh and IBM computers, but this file type can not be used on the WEB.

JPEG - This raster file format permits an image to be compressed in size and can be viewed on Mac, IBM and UNIX computers. This file type is frequently used on the Internet for photographic images.

GIF - Graphics Interchange Format is a raster image file type that supports 256 colors. It can be read on all computer platforms and is the most widely used file format on the Internet. (Gif87 since it was first introduced in 1987) GIF images are easily converted into an animation using a variety of software programs available on the Internet for Free (e.g. Gif builder, Gifcon.exe).

Gif89a - introduced in 1989, permits transparency and interlacing

PNG - Portable Network Graphics file. This is a new file format that hopes to replace the patented GIF files. This file format can include 16.7 million colors, 256 colors, or 16 bit gray scale. PNG files are interlaced. These images can include gamma correction (brightness correction) to account for different monitors. There is just one problem, only Internet Explorer 4.0 currently supports this file type. Netscape version 4.1 and greater are supposed to support it. So it may become an important file format in the future. For more information see www.wco.com/~png for up to date infortmation on this file format.

There are a number of programs that can convert one file to another. On the IBM platform I use HiJaak Pro and the Mac I use Adobe Photoshop and Adobe Streamline. Paintshop Pro can also convert many file types. Vector based artwork for the WEB is now available allowing users to "zoom" into a picture without the images becoming pixelated. These type of images are useful for putting maps on the Internet. An animation program that can create vector based images for the Web is Macromedia Flash.

To determine the file size of an image, most programs will tell you this when you re size the image. You can also right click on the image and view properties in Win 95. On a Mac click once on the image icon and then go to File Menu and View information to see how large the image file is. See the appendix to see how you can determine the file size from the dimensions of the image and the scanning resolution. Image file sizes for the WWW should be as small as possible in order that they load quickly. As a rough guide, it takes approximately one second to download one kilobyte with a 14,400 bps modem. A 100 KB file would take approximately 100 seconds under optimum conditions. If a web page does not download quickly, web surfers are likely to go elsewhere. If you plan on putting many images on a web page, keep their file sizes small or use small thumbnails and link them to larger images.

REFERENCES

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AGFA (1994) An Introduction to Digital Color Prepress Vol 1 and Vol II. I ordered these books directly from AGFA at 200 Ballardvale Street, Wilmington, MA, USA, 01887.

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APPENDIX

How bit depth determines number of colors and image file size.

Bit depth - a bit = 1,0 on the computer. To produce 256 gradations of gray a computer needs to code the information in 8 bits e.g. 11111111 or 10101010.

A B & W laser printers best only output is only about 64 shades of gray, so 8 bits is fine for image editing if you only plan to output the image on your laser printer.

If you working with color you need 8 separate bits for each color: R,G, B. to have 256 shades of each. Since you have 8 bits for each color 3 x 8 = 24 bits or 16.7 million colors. Since a bit can either be a 1 or a 0 there are two possibilities.

2 to the power of 8 = 256 28 + 28 + 28 = 224 = 16.7 million colors . If you work with color photographs I recommend at least working in 16 bit color mode or 65,000 colors (216 = 65,536). Most computers do no support more than 256 colors unless they have additional VRAM (video ram) installed, or a special graphics card. If you plan to manipulate images make sure your monitor can support at least 65,000 colors. Note 65,000 is the maximum number of color a laptop computer supports with an active matrix screen.

Memory requirements : calculating the file size of an image (8 bits = byte).
color image size = dpi2 x picture dimensions (l x w in inches) x 3 (24 bit)

e.g. 5 x 7 inch B & W print (72 dpi) 5 x 7 x 72 x 72 x 1 = 180 Kilobytes
5 x 7 inch color print (72 dpi) 5 x 7 x 72 x 72 x 3 = 544 Kilobytes
5 x 7 inch color print (400 dpi) 5 x 7 x 400 x 400 x 3 = 16.8 Mbytes

8 x 10 inch B & W print (72 dpi) 8 x 10 x 72 x 72 = 1.2 Mb
8 x 10 color (72 dpi) 8 x 10 x 72 x 72 x 3 = 3.6 Mb

8 x 10 inch color print (400 dpi) 8 x 10 x 400 x 400 x 3 = 38.4 Mbtyes

You can see that an 8 x 10 inch print scanned at 400 dpi results in a large file nearly 40 MB in size. Large files require a lot of space on your hard drive or other storage medium unless you compress the file.

If you are scanning images with the intention of having them printed
then you want to use about 2:1 dpi or ppi to lpi (dpi = ppi). lpi or lines per inch refers to halftone dot ratio or screen frequency - the higher the lpi the greater the number if shades of gray that can be printed.

Newspapers are printed at 65-85 lpi, Magazines 100-150 lpi , Books 150 - 300 lpi

Digital imaging is moving at the speed of light anything you read here is likely going to be out of date so be sure to check with recent magazines and camera stores for the latest digital imaging equipment. The Internet is also a great resource for keeping up on the field.