

An Overview of

Scanners

&

Scanning

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Basics

- Scanners sample the intensity of light beams passing through or reflecting from images and convert the readings into streams of red, green and blue brightness values.
- Brightness values are scaled into the range of 0 to some maximum value which is normally a power of 2 minus 1 such as 255 (8-bits) or 65,535 (16-bits), for instance.
- The scanner, along with the control program in the computer, collects the light samples, organizes them and stores the finished product as a file on the computer's hard drive.

Sampling

- The scanning process divides an original into a grid of equal-sized square sample regions.
- The scanner mechanism causes a beam of light to pass through or strike each sample region and directs the transmitted or reflected light to a sensor.
- The sensor separates the light into red, green and blue components and measures the intensity of each color component by converting it to a voltage.
- Voltage is converted into a digital value from 0 to the scanner's maximum output value by an ADC.
- Digital values are packaged as either 8-bit or 16-bit results depending on the capability of the host software and user need.
- The collection of digital values is organized into an industry standard form and stored as a file on the host computer.

Technical Terms

- **DPI** - Dots per inch. Interchangeable with samples per inch. Corresponds to sampling region size ($1/\text{DPI}$). For example, if the scanner samples a region 0.001" on a side, it is sampling at 1000 dpi. DPI are always published as a figure of merit usually in the range of 1200 to 4800. Higher numbers may represent interpolated values.
- **Resolution.** Number of samples taken per unit length usually given in DPI. Numbers given by manufacturers may show more resolution in one direction (height) than the other (width) such as 2400x4800. This is because the moving parts of the scanner can advance in increments smaller than the CCD cell separation.
- **Dynamic range.** Relates to the range of light intensity values that can be discriminated by the scanner. The range is between D_{\min} and D_{\max} . Seldom published.

Technical Terms

- **Dmin** - Dynamic range minimum. Relates to how well the scanner discriminates the lightest sections of the image from the ambient light. Seldom published since usually assumed to be zero.
- **Dmax** - Dynamic range maximum. Relates to how well the scanner discriminates the darkest sections of the image from black. Almost always published as a figure of merit usually in the range of 3 to 4+. High Dmax is important only if you're scanning positives; not so if you're scanning negatives.

The theoretical limit of Dmax with 16 bits of data is 4.8. This is because Dmin and Dmax are on an exponential scale (like the Richter scale for earthquakes). Note that $10^{4.8} \sim 65535 = 2^{16} - 1$.

Many believe that manufacturers tend to overstate their Dmax capability. For instance the \$30,000+ ICG 380 drum scanner claims only a Dmax of 4+ while Nikon claims a Dmax of 4.8 for its \$2,000 Coolscan 9000 ED film scanner!

Technical Terms

- **Interpolation** - A process used to fill in values between samples. Often used to achieve maximum rated resolution but adds no new information. A scanner with an optical resolution of 1200 dpi and able to step 2400 dpi (1200x2400 dpi) must interpolate the optical scan to reach 2400x2400 dpi and have square samples.
- **Analog-to-Digital Converter (ADC)** - A device that takes voltages in a particular range and produces a linear digital output in a corresponding range (for example, 0 to 5 volts in generates values from 0 to 255 out). Used to convert light readings to digital values. Capacity of a scanner's ADC is partially responsible for the Dmax value.

Scanner Types

- Drum
- Film
- Flatbed
- Digital cameras

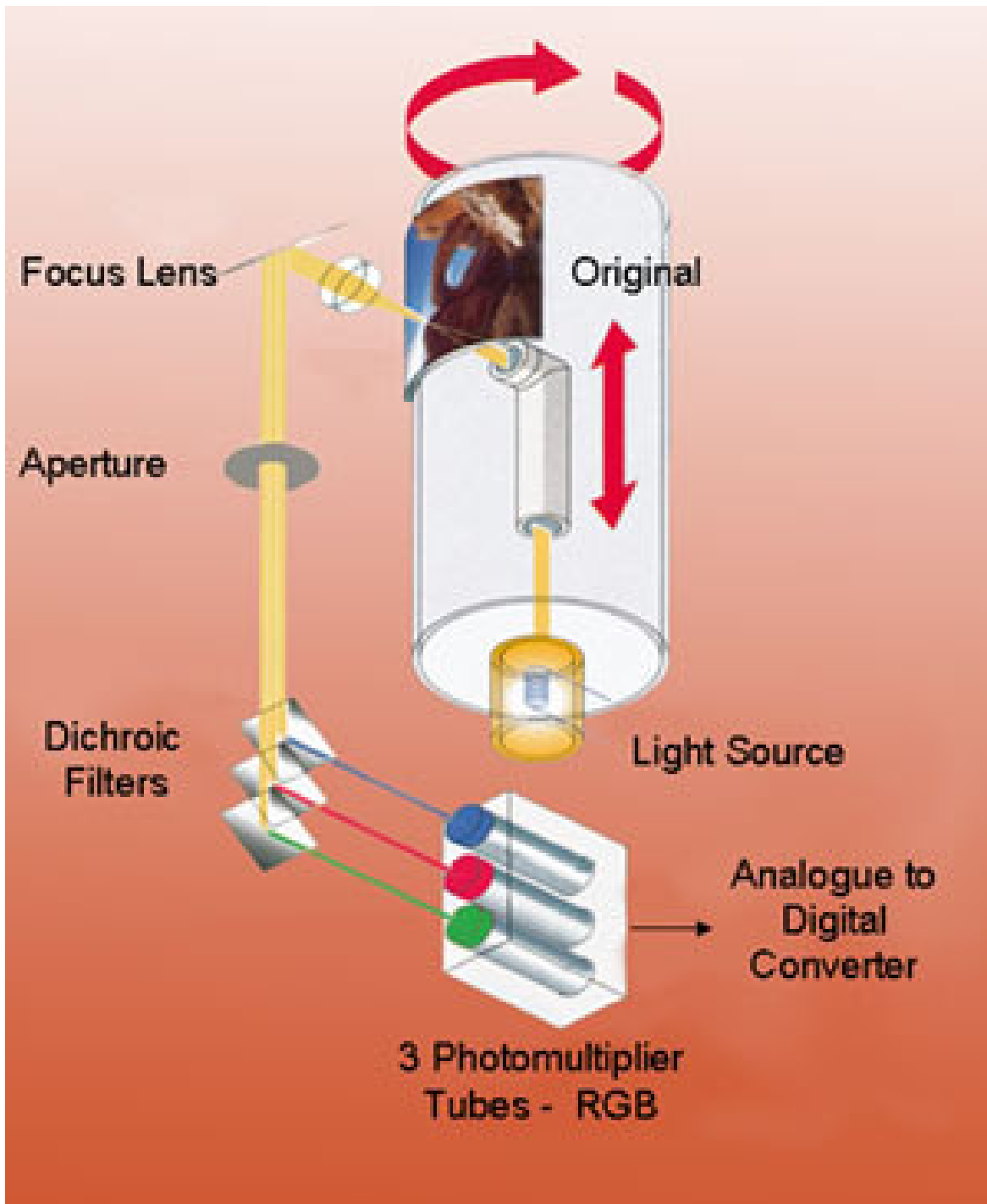
Drum Scanner Features

- Original is spun on a rotating drum.
- Sampling is performed using a high intensity light source such as a laser or quartz-halogen lamp and photomultiplier tubes.
- High resolution (12000 dpi typical).
- Wide dynamic range (real 3.8 to 5.0).
- Excellent color rendition is a key attribute of the drum scanner.
- Oil coating of original is an option.
- High cost (\$20,000+).
- Can handle a wide range of original types including film and reflective.
- One sample dot processed at a time (vs. line at a time for CCD or area at a time for digital camera).

Drum Scanner Operation

- The original is mounted on a transparent drum. A film original may be coated with oil to eliminate Newton's rings, dust and scratches.
- The drum spins at ~ 2000 rpm around a precision focused light source which moves from one end of the drum to the other.
- The light passes through or reflects off of the original into a lens system leading to a set of photomultiplier tubes.
- As the drum turns the light moves across the original causing the photomultiplier tubes to generate output voltages in response to the incoming light intensities.
- The photomultiplier tube voltage outputs are converted to digital values by an analog-to-digital converter.
- A stream of digital values is created which is collected and saved for the host computer.

Drum Scanner



Drum Scanner



ICG 360

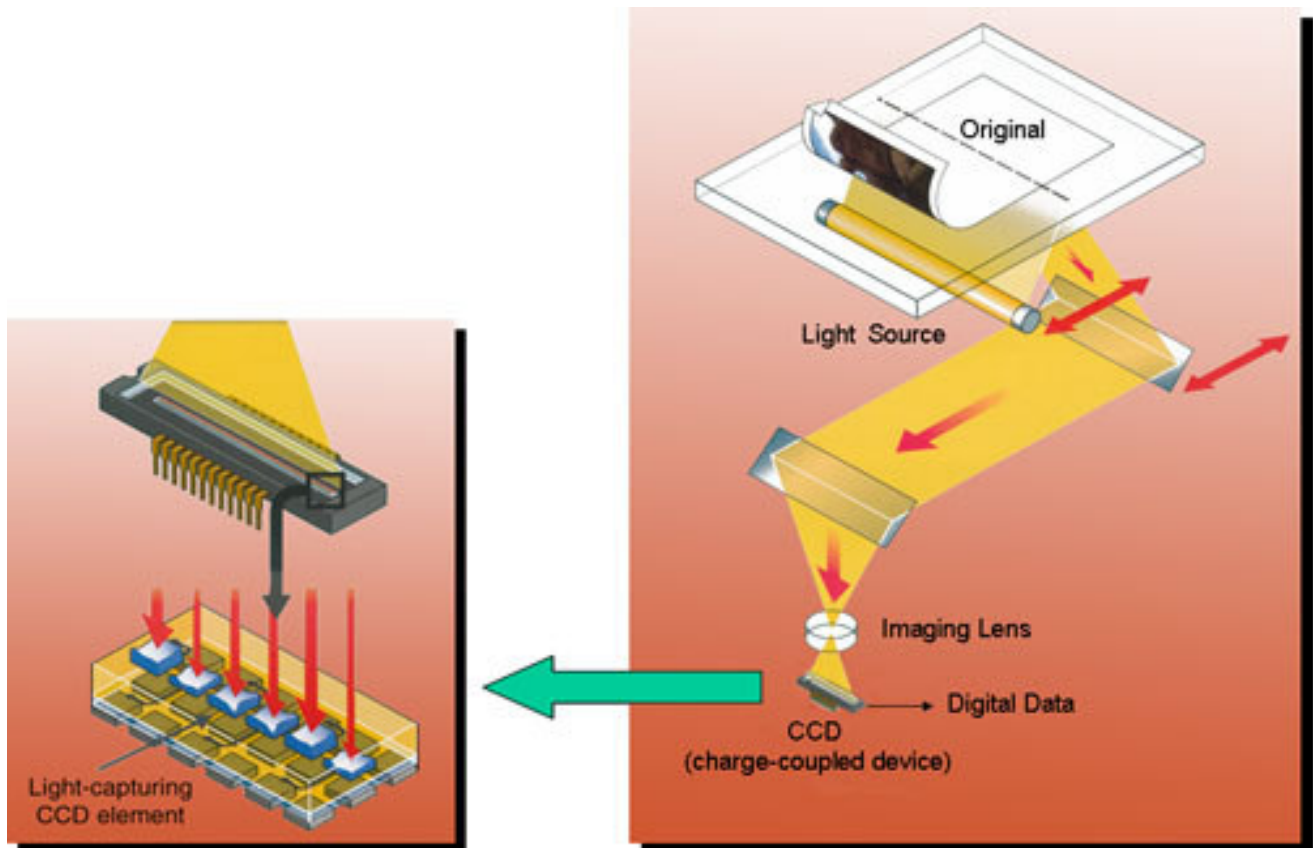
Film Scanner Features

- Original is scanned flat either in a holder or a drawer.
- Scanning is performed using either a fluorescent lamp or LEDs and linear CCD arrays.
- Medium resolution (1200 - 4800 dpi typical).
- Medium dynamic range (~ 4).
- Very good color rendition.
- Medium cost (\$300 - \$2000).
- Dedicated to scanning film.
- Come in 35mm-only configurations and multi-format units that include 35mm, 120/220 and larger film formats.
- A line of samples is processed at a time.

Film Scanner Operation

- The original is mounted in a holder or tray and inserted into the unit.
- A stepper motor causes a narrow bar of light to move across the film.
- Light passes through the original onto a linear array of charge-coupled devices (CCDs).
- The CCD array generates output voltages in response to the light levels.
- CCD voltage outputs are converted to digital values by an analog-to-digital converter.
- A stream of digital values is created which is collected and saved for the host computer.

Film Scanner



(Note that in a film scanner the light is on the opposite side of the original as the sensor.)

Film Scanner



Minolta Dimage Scan Multi Pro

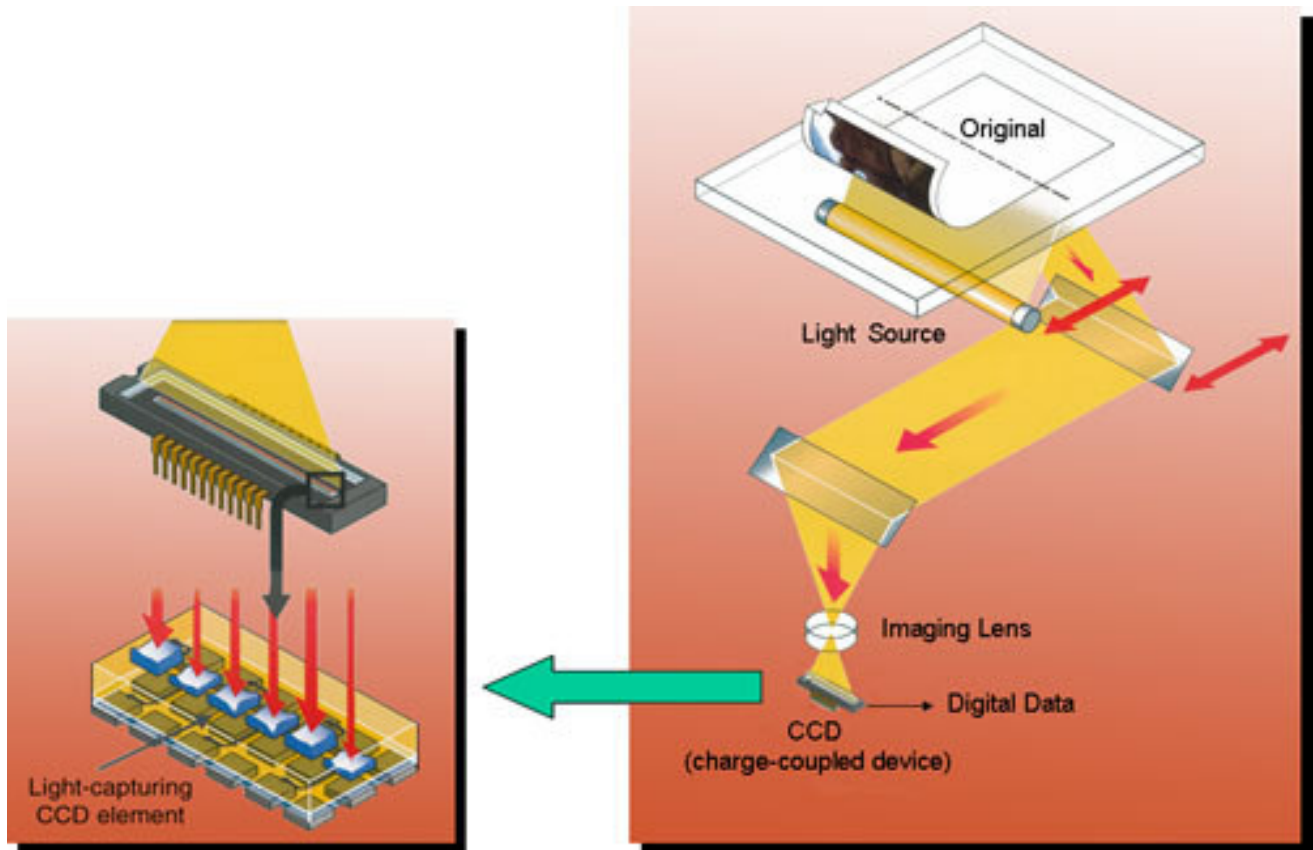
Flatbed Scanner Features

- Original is scanned flat - usually on a glass surface, film is usually mounted in special holders or drawers.
- Scanning is performed using fluorescent lamps and linear CCD arrays.
- Medium resolution (1200 - 4800 dpi typical).
- Medium dynamic range (<4).
- Good color rendition.
- Reasonable cost (\$100 - \$1000).
- A line of samples is processed at a time.
- Can be used to make direct images of objects placed on the glass - coins, jewelry, flowers, fabrics, etc.

Flatbed Scanner Operation

- The original is placed onto the scanner's glass surface or, in the case of film, it's placed in a holder on the glass surface. In some cases film may be inserted into a drawer.
- A stepper motor causes a narrow bar of light to move across the original.
- Light passes through or reflects off the original onto a linear array of CCDs.
- The CCD array generates output voltages in response to the incoming light levels.
- CCD voltage outputs are converted to digital values by an analog-to-digital converter.
- A stream of digital values is created which is collected and saved for the host computer.

Flatbed Scanner



(Note that in a flatbed scanner the light is on the opposite side of the original as the sensor for film and the same side for opaque.)

Flatbed Scanner



Epson Perfection 4870

Computer Interface Standards

- SCSI, SCSI-II, Ultra SCSI
- FireWire (IEEE1394)
- USB, USB 2.0
- USB is probably the easiest to deal with when it comes to adding peripherals to your system.
- SCSI is perhaps the most difficult of the scanner interfaces to work with. Also, the boards can be pricey, especially from Adaptec. Supported in most Win systems and all Mac systems.
- FireWire may not be supported by your scanner software in all Win systems. Well-supported in current Mac systems.
- Be sure your computer has or can accept an adapter card for the interface standard required.
- Make sure you're getting the correct interface and cable for your system. This is particularly true with SCSI which has many variants.

Software

- Most scanners today come with lots of software bundled in. Carefully consider what you're getting. Some of the packages cost hundreds of dollars purchased separately.
- Read some of the third party reviews to see if the software meets your needs.
- A third-party scanning package such as SilverFast Ai can improve your scanning results especially if you're using an older scanner. You can download a trial version for free from their web site (see below).

SilverFast is also especially recommended if you scan negatives since it has a data base of most film base characteristics (profiles) allowing it to correctly adjust and process most negatives.

- Many people like VueScan which is considerably cheaper than SilverFast. You can download a trial version for free from their web site (see below). Has many of the same features as SilverFast.

SilverFast Ai

- SilverFast is third-party scanning software from LaserSoft that can add value to your scanner operations.
- It's the Photoshop of scanning software.
- Has dust and scratch removal, unsharp masking, selective color to gray conversion, profiler, 16-bit scanning and many other features.
- Unique ability to correctly scan negatives.
- If you're considering buying a new scanner, look for one with SilverFast Ai bundled in.
- Buying SilverFast Ai separately can be \$300 or more.
- SilverFast can be worth it to spruce up an existing scanner though. A Umax Powerlook III scanned almost 10 times faster with SilverFast Ai and made a better image than the software that came with it.

Digital ICE

- Consider a scanner with Digital ICE.
- Digital ICE is a proprietary technology built into many scanners to remove dust and scratches.
- It uses an infrared beam to scan the film. Since the film stock is transparent to infrared light and the dust and scratches are not, it can create a separate channel of just dirt and noise information.
- The dirt and noise channel is electronically deleted from the scan with little or no change to the underlying original image. It can be a big time saver.
- Was an Applied Science Fiction product - now a Kodak product.
- Digital ICE cannot be used with any film that is opaque to infrared light such silver-based B&W. Kodachrome may also be a problem but there is a new version of Digital ICE for Kodachrome.

Digital ICE Example



Before Digital ICE



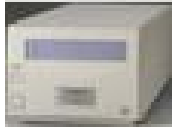


After Digital ICE

How To Choose a Scanner

- If your work requires the utmost in color accuracy and resolution, consider having it drum scanned.
- If you deal exclusively in 35mm film format, consider a dedicated 35mm film scanner. They can have many conveniences such as batch scanning.
- If you deal in 35mm and 120/220 or just 120/220 film format, consider a multi-format film scanner.
- If you work in larger film formats such as large 120/220 panoramics, 4x5 or larger, consider a high-end flatbed scanner.
- If you need to scan film and reflective originals, then consider a high-end flatbed scanner.
- If your needs extend only to reflective originals, consider a low-end flatbed scanner since the higher-end models don't deliver any extra value.
- Consider a mixed approach - use a lower-end scanner to proof your work and use a drum scanner for the final product.

Some Current Film Scanners

High-End Models (>\$1200)

	<p>Minolta Dimage Scan Multi Pro 35mm, 120/220 and other formats 4800 dpi, 8- and 16-bit, 4.8 dmax</p>
	<p>Nikon Super Coolscan 9000-ED 35mm, 120/220 and other formats 4000 dpi, 8- and 16-bit, 4.8 dmax</p>
	<p>Microtek Artixscan 120TFT 35mm and 120/220 formats 4000 dpi, 4.2 dmax</p>




Some Current Film Scanners

Mid-Level Models (<\$1200)

	Nikon Super Coolscan 5000-ED 35mm format only 4000 dpi, 16-bit, 4.8 dmax
	Microtek ArtixScan 4000tf 35mm format only 4000 dpi, 4.2 dmax
	Nikon Coolscan V-ED 35mm format only 4000 dpi, 16-bit, 4.2 dmax
	Pacific Image PrimeFilm 3650-Pro3 35mm format only 3600 dpi, 16-bit, 3.6 dmax





Some Current Flatbed Scanners

High-End Models (>\$500)

	Epson Expression 1680 Pro Opaque and film (w/ opt. adapter) 1600 dpi, 16-bit, 3.6 dmax
	Epson Perfection 3200 PRO Opaque and film 3200 dpi, 16-bit, 3.4 dmax
	Microtek Scanmaker 8700 Pro 35mm and 120/220 formats 1200 dpi, 3.6 dmax

Some Current Flatbed Scanners

Mid-Level Models (<\$500)

	Epson Perfection 4870 Opaque and film 4800 dpi, 16-bit, 3.8 dmax
	Microtek Scanmaker 6800 Opaque and film 2400 dpi, 16-bit
	Hewlett Packard Scanjet 8200
	Canon CanoScan 9900F Opaque and film 3200 dpi, 16-bit

Where & How To Buy a Scanner

- B&H - BHPHOTOVIDEO.COM (7-day return policy)
- Adorama - ADORAMA.COM (14-day return policy)
- Amazon - AMAZON.COM (30-day return policy)
- Ebay - EBAY.COM (make sure you buy from a reputable seller with lots of good feedback and who allows returns)
- Make sure of return policies for scanners. Not all scanners live up to their claims. The specs are meaningless if you don't get the results you need and expect.
- Read promotional material carefully to be sure the scanner you're buying is supported by your computer system and has the software you need included. Changing operating systems, buying new adapter cards and cables and additional software can get very expensive.

Profiling Your Scanner

- You should profile your scanner regularly.
- When selecting a scanner, make sure it contains profiling software or is at least an available option.
- Profiling software can be purchased after the fact but can be much cheaper if bundled.
- Profiling is simple and consists of scanning a standard target (IT8) and having the software compare the color values to the known standard.
- Maintain the target with the same care as your own originals.

Scanning Tips

- Clean your original carefully with a good brand of duster.
- Clean any glass surfaces involved frequently since dust settles continuously.
- Perform as many corrections as you can to the image during scanning. There will never be more information present about the image than at that time.
- Give your scanner time to warm up before starting. Lamps can take time to reach steady-state, sometimes up to 15 or 20 minutes.
- Profile/calibrate frequently.

Follow-Up Reading

- "Mastering Digital Scanning" by David D. Busch. A comprehensive guide.
- "SilverFast - The Official Guide" by Taz Tally. Has some useful general information in addition to the SilverFast specifics.
- Ken Rockwell web site (KenRockwell.com). Covers many aspects of scanners and related subjects in great depth. Makes many specific recommendations.
- Applied Science Fiction site (asf.com). Read about Digital ICE and other scanner-based image improvement and correction technologies.
- LaserSoft site (lasersoft.com). Read about SilverFast and see if it's available for your scanner.
- Hamrick Software site (hamrick.com). Read about VueScan and see if it's available for your scanner.

Follow-Up Reading

- Manufacturer's sites can be found on the B&H site (Bhphotovideo.com) under "Links & Resources" on the lower left side of the home page.

Post-meeting Addendum

You might want to sign up for Tim Grey's email newsletter. He manages to have something interesting to say in almost every daily letter. Sign up at: www.timgrey.com

Will Crockett's website has a lot of info that you might be interested in: www.shootsmarter.com

(Crockett caters to the professional portrait and wedding shooter, but he gives good practical advice.)

Ken Rockwell has a wide range of information on photographic technique and equipment. Strongly opinionated - which can be a good thing.

www.KenRockwell.com

(Rockwell can be opinionated to the point of being a know-it-all. Beware of people who strongly express simple opinions about complex issues!)

Two third-party scanner software packages were discussed at last night's meeting:

www.lasersoft.com Web site of SilverFast, a comprehensive, if not cheap, scanning software (it made my Umax PowerLook III go 10 times faster)

www.hamrick.com Web site for VueScan, a cheaper alternative to SilverFast.

(Editorial comments added by Tom Judd)