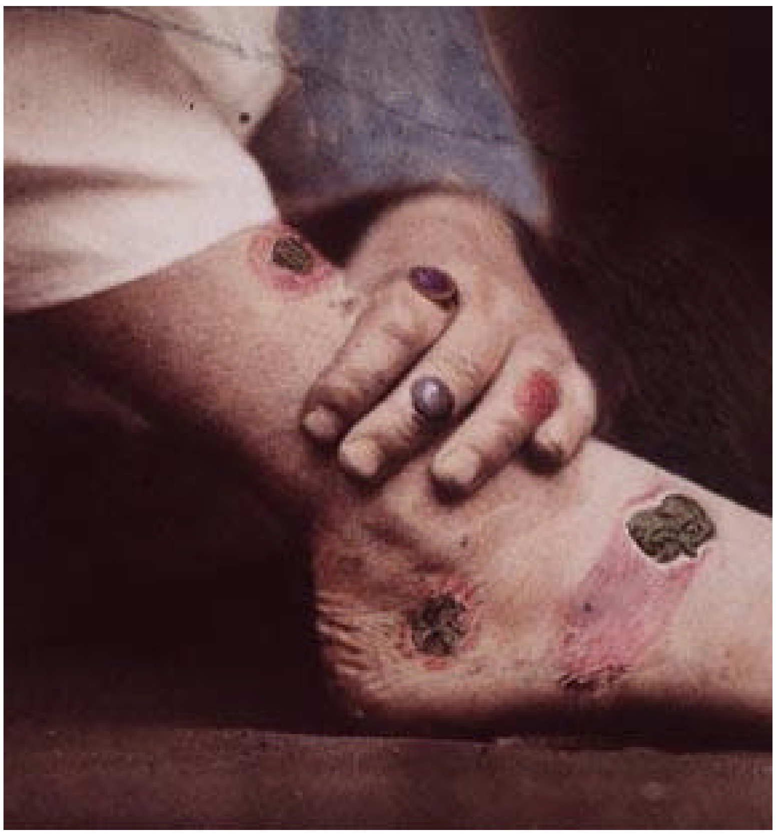
Practical Approaches for producing inexpensive digital Photography in the Dermatology Office

part one



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Abstract: Filmless Photography

Similar to their computer counterparts, digital cameras are rapidly shrinking in size and dropping in cost. In preparing this article, which investigates issues of; the mechanics of digital cameras, the software which supports image transmission, the use of, and printing of the digital image, there is one absolute certainty; new, less expensive, and more capable digital cameras will be continually introduced, while the existing cameras will continue drop in price. This two-part article will describe the significance of the digital photography revolution, for both office-based practice and dermatologic education. The review will initiate those currently not using digital photography to the new technology, through a comparison to traditional film based dermatologic photography. The goal is to explain the new medium in a sensible and easily understood manner. Upon completion of the first part of this two part series, readers should understand the technical basics of making a digital image, transferring the image and storing the image. An office-based guide to camera basics will be provided, with emphasis on low cost solutions.

In part 2, archiving digital images for office based records and consultation will be discussed. Digital image databases for dermatologic residency education and image archives will be explored. The manipulation of digital images through image processing software will be overviewed, as well as the printing of and presentation of digital images investigated. The review will conclude with an overview of digital photography and its application to telemedicine.

Importance of photography and imaging in dermatology.

Photography has proven itself to be a valuable aid in many aspects of medicine, which includes dermatology. Dermatologic care, research and publishing have been enhanced through the use of images. For instance, photo-documentation of patients with atypical nevi, skin cancer, or chronic ulcers, assists the clinical assessment by providing objective measures of the clinical exam over time. Dermatology pictures are also the basis for teledermatology (telemedicine), are sometimes requested by insurance reimbursement plans and are used throughout medical education. Additionally, the documenting of procedures for legal (malpractice) issues has taken on a greater significance in this era of litigation. Traditionally images are used to communicate the fundamental morphologic and distribution patterns of the disease process itself. Images are central to traditional dermatology publishing, and are likewise critical to the new media of the Internet and computer based applications. The Internet provides a new channel for resident and continuing medical education but also allows for the transmission of images for tele-medical purposes. As the ability to make, save, retrieve, print or transmit images continues to get faster, so will the volume and use for the approaches.

Historical Perspective
The earliest known daguerreotype used for medical photography was likely made in 1845, by the Parisian Alfred Donne[1]. During the 150-year interval since the birth of medical photography, dermatologic photography has evolved into widespread use. Images of skin disease are used to illustrate texts and journals, and have become a vital component to patient care component within offices. The 150-year journey has been marked by a series of technologic advances.

Neuse[2] has provided an excellent historical survey of these compelling transitions beginning with Donne's first medical daguerreotype, followed by the hand colored photographs of the late 19th century, the first medical stereoscopic photographs in Germany, the half-tone "heliogravure" images of Fox beginning in 1878, the first portable camera developed by Eastman, the 1914 introduction of true color photography and finally stabilizing with the modern Kodachrome® slide films, as well as the E-6 Ektachrome film types.

From the author's perspective, digital photography then becomes the next milestone in the evolution from the first daguerreotype into modern practice. Sony® first introduced digital photography in 1981. Although quite primitive, still video technology was used as one of the first methods utilized. The ProMavica, a product for the professional community, later replaced Sony's camera, the Mavica, an acronym for magnetic video camera.[3] During the time interval, from 1981 to present, digital photography has undergone astonishing growth, particularly within the past three years. Further, the almost algorithmic reduction in price appears to be coupled to remarkable achievements in image quality and camera features.

Defining a good dermatologic image
The process of making a picture has become virtually automatic. There is currently camera equipment so "smart", that it can be programmed to make pictures without operators. Imagine, simply tell the patient to go to room 6 and stand in front of the gray wall. Auto exposure, auto focus, self-timed, flash, read/write to the hard drive and the process is complete. With the exception of possibly aiming the camera, all the photomechanical controls have become so integrated, that camera operators could conceivably become non-essential personnel. Futuristic visions extend beyond the preceding brief description, including automatic recognition of changing nevi and pattern analysis resulting in computer diagnosis of melanoma.

The aim of this review is to provide the knowledge necessary to use digital photography today. This review is written with the belief that the camera, regardless of technologic advances, will in the foreseeable future require, at least, a semi- skilled operator. There is

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[1] [1]Donne A, Cours de Microscopie Complementaire des Etudes Medicales, Paris France
[2], Neuse, Wilfried H.G. et alArch Dermatol, Vol. 132, Dec 1996 1492-1498.

J. Larish Focal Encyclopedia of Photography Focal Press1993
ISBN 0-240-80059-1

also the absolute that the overarching themes are far more critical than specificity. The world of electronic imaging is completely dynamic.

Before discussing the specifics of some relatively inexpensive digital cameras and effective methods for using them, it is important to re-iterate that basic and sound medical photography approaches are still needed independent of the capture media. These techniques have been described by H.Lou. Gibson, and include the need to properly compose the image, remove all distracting clothing and jewelry, provide a neutral backdrop, etc. There are many excellent references on the topic of medical photography and its practices including Biomedical Photography by Vetter, Medical Photography by Peter Hansell, as well as Clinical Photography by H. L. Gibson

Choosing the Digital Direction

One cannot pick up a newspaper, or photographic trade publication without reading (or seeing an advertisement) for a new digital camera. Similar to the market-place confusion associated with computer hardware purchase, there exists an equipment decision-making conundrum in the digital-imaging environment as well. Digital cameras, like computers are constantly becoming, "cheaper, faster and better". The often heard statement that one will delay purchase of equipment until equipment costs have stabilized means that this fundamental equation is not understood, as the price of the equipment reaching an imaginary "bottom" level will simply not occur. The inevitability of this market phenomena continuing seems certain, the personal decision of when to purchase, what to purchase, and how to achieve reasonably good results is not as clear.

The entire imaging system needs to be considered and integrated as much as possible when thinking about the fundamental question of what to purchase for your office, laboratory or residency clinic. For example, the size of your practice and the number of patients to be imaged will effect how much computer storage you will require. You will not need to buy film, but you will likely be ordering a hard drive with gigabytes of storage, or use a writable CD-ROM media or optical media system with magnetic back-up tape. As with any computer application, your system will need a "back-up" system for restoring lost data when the system fails or "crashes". These details, are not ancillary, but are integral to the decision making process, of which camera to purchase. Issues related to storage and back-up will be fully addressed in part II. The number of images created at a particular resolution that can be produced will be determined by the camera type, which will influence how and where the images will be stored which will influence the type and size of permanent storage media chosen. None of the issues are that complex alone. Identifying the goals of the practice's digital direction, such as how the images will be used, is the central and first step into the digital world.

It might be useful before going further to establish a glossary of terms list to facilitate a better understanding of the bulk of this article.

Glossary

Adapter(card) Most memory cards will be different manufacturer to manufacturer. They maybe referred to as ATA cards, or by their various proprietary names such as Smartmedia, Memory sticks , Compact Flash or film cards. These various devices will often require an adapter to be used for reading in a computer. The adapter will have minimal impact on image transfer speed

Aliasing Low and Medium resolution computer imaging systems normally create and display images with smooth edges. When image artifacts exist they may appear as jagged edges. They are often a result of under sampling or created when the detail exceeds the rendering ability of the system. There are several image processing approaches to reduce the visual aspect of this phenomena.

Area Array This is a method of pixel organization in a Charged Couple Device(CCD). In this method, pixels are located both in the horizontal as well as vertical orientations(x, y matrix). There will exist a finite number of pixels in each direction dictated by the manufacturing of the CCD.

Bit[4] A bit is the smallest unit of data in the digital world. As a basic unit, it can be off (0) or on (1). In imaging applications, the more the bits, the greater the tonal ranges possible. A grayscale image is an 8 bit image and will display 256 different tones(2) 8. There are _ bits in a byte while a megabyte is 1,000 bytes. Because RGB(red green blue) images have three channels, an RGB image is described as being 24 bit.

Bit depth Brightness resolution refers to the number of shades of gray an image can display that is assigned to each pixel. The more bits the greater the tonal range possible. . A grayscale image for example that is an 8 bit image will display 256 different tones (2)°.

Bitmap[5] A pixel by pixel description of an image that is observable. When the resolution is high enough, the image is seen as a continuum however when there is insufficient data, there will be the appearance of image pixels.

Buffer Memory An intermediate location in an electronic imaging system. A system with a large buffer memory will allow faster functions such as acquisition, reading and writing to occur. More advanced systems will have greater function in this system feature

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[4] R Kraus Focal Encyclopedia of Photography Focal Press1993 ISBN 0-240-80059-01

[5] R Kraus Focal Encyclopedia of Photography Focal Press1993 ISBN 0-240-80059-01

CDI A compact disk that is interactive is a new standard and used with disks containing still images, moving image, image sequences or audio tracks. A CDI device allows a user to interact with the media and it requires a special player and monitor

CD-ROM are disks that hold text, images or sound are a major means of storage and distribution of electronic data. The typical CD-Rom storge capacity is 650mB. CD-ROM players are standardized at 150Kbytes per second. ROM refers to, read only media

CCD[6] refers to Charged Couple Device and is an array of photo sensors that detect light and produce readouts as electronic signals. It is often described as a function of its resolution.

CMOS chip is yet another architecture used in chips. In the active pixel CMOS method, the electrical power design has been modified to use power more effectively by linking pixels together to lower power requirements. CMOS chips are not capable of higher resolution simply are more efficient. To find CMOS technology more integrated into digital cameras will require industry to reinvent manufacturing.

CPU is the heart of any computer and often refers the computer's black box to which everything is connected. Specifically the CPU is the microprocessor in a single integrated chip. The vast majority of computers use Intel(PC) or Motorola(MAC) microprocessors. The CPU is responsible for executing software instructions and manipulating data.

Display monitor[7] The common monitor in an electronic imaging system is a device for displaying images and is a cathode ray tube or CRT. It is coated with bands of phosphors that produce red, green and blue color. The calibration and brightness of this device is a total variable in the electronic imaging world.

DPI Dots Per Inch. Similar to PPI or point/pixels per inch

Dynamic Range Scenes and subjects contain various brightness or reflectance within them. The difference between the region of highest brightness as compared to the region of least brightness describes a scene brightness range or dynamic range. CCD's record data more effectively when using a narrow brightness range similar to color slide films. High brightness ranges create problems for chip response.

J larish[6] Larish Focal Encyclopedia of Photography Focal Press1993 ISBN 0-240-80059-01

[7] J Larish Focal Encyclopedia of Photography Focal Press1993 ISBN 0-240-80059-01

Dye Sublimation — Refers to a process where a pixel for pixel image is written to a hard copy output device. This type of printing is referred to as a continuous tone image and is considered to exhibit the highest degree of data or similarity to photographic paper. Receiver material are exposed to cyan, yellow, and magenta dyes and is transferred by heat to the receiver material. This type of print is capable of rendering 300 dots per inch and is the most expensive type of digital printer.

E-6[8] A process used to develop certain types of color slide films. Typically Ektachrome®, FujiChrome® as well as other major manufacturer's films are compatible with such a process. The E-6 process is approximately 44 minutes dry to dry. The process creates color dyes in three separate emulsions. The stability of such dyes has been the subject of vigorous study and is considered to be, under average storage and usage up to 75 years.

Hard Disk — Hard disks use a series of rigid platters that can be recorded to(write) and played back(read). In much the same way as a floppy disk operates, these drives are built into computers. The plates that are used in hard drives typically have very large capacity. Current drives may hold up to 10 Gigabytes of data for a relatively nominal fee. Hard disks use parallel methods to talk to each other and demonstrate response times of 15 milliseconds. This method of data storage is currently one of the fastest available

Ink Jet[9] — a computer controlled output device that sprays ink through fine nozzles. The physical size of the nozzle opening determines the dot size. Typically water based inks will be sprayed in liquid form. These type printers can resolve between 100 and 30 dpi. It should be noted that this type of device is not considered a continuous tone device

Interpolation[10] — is a method of modifying the image size. Digital systems are capable of recording a fixed number of pixels. Sometimes there may not be enough pixels for a particular application or there may be too many and software may be called on to change the amount of pixels. This type of image processing is defined as interpolation.

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[8] Current, Ira Materials & Processes of Photography Focal Press, Boston, Mass c 1986 ISBN 0-240-51752-0

[9] Kraus, R Focal Encyclopedia of Photography Focal Press1993 ISBN 0-240-80059-01

[10] Kasai & Sparkman, Essentials of Digital Photography, New Riders Press, ISBN 1 - 56205-762-6

Kodachrome[11] is the original color slide film invented by the Eastman Kodak in 1935. The film emulsion is actually a B & W film and the cyan , magenta and yellow color dyes are added during the K-14 processing. Kodachrome has been an industry standard for many years because of its image permanence, although E-6 films now boast a very similar life expectancy and are more easily processed in a shorter time

LCD[12] Liquid Crystal Display is method used for displaying images and is typically used on a small devices, some overhead projectors and laptop computers now use them. Individual pixels are controlled by a liquid crystal matrix or active matrix system.

Linear array is another method of pixel organization in a Charged Couple Device(CCD). In this approach, a single row of pixels is located in only the vertical orientations(y matrix). There will exist a finite number of pixels in this direction dictated by the manufacturing of the CCD just as in the area array device. The number of vertical pixels is fixed and the array is moved across the field using a small motor.

Memory card digital image files are stored on this temporary location in digital cameras. The memory card is capable of reading and writing both while in the camera or in a card reader inserted to the CPU. Different names have been given by each company to its memory card. Some names for example would be Smartmedia, memory stick, PCMCIA, or Compact Flash.

Pixel[13] A picture element, the smallest component of an electronic picture that can individually be processed in an electronic imaging system

Photo CD[14] is a proprietary product from the Eastman Kodak Company. Originated from film pictures, these images are scanned onto the disk at 5 various resolutions. The disk has the potential to hold up to 100 images in these 5 resolution formats. This product has had a major adoption in the area of desktop publishing where various stock images are sold this way.

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11 Robert Hirsch, Colore Photography W C Brown Publishers, Dubuque, Iowa, 1989 ISBN 0 -697-06132-9

12 Teres, M Focal Encyclopedia of Photography Focal Press1993 ISBN 0-240-80059-01

13 L Stroebel Focal Encyclopedia of Photography Focal Press1993 ISBN 0-240-80059-1

14 Zigon, Tom Focal Encyclopedia of Photography Focal Press1993 ISBN 0-240-80059-1

RAM[15] random access memory is the part of a computer where data is temporarily stored. It represents the computer work space. The act of placing data in memory is referred to writing to while the process of obtaining data is known as reading from memory. RAM is volatile in that once the power supply is removed the memory is not archived. For image processing requirements, a lot of RAM is imperative.

Resolution[16] In electronic imaging systems, the number of horizontal and vertical pixels that comprise the image. Typically the minimum pixels required for scientific images is 512 x 512. If the term is used to describe brightness levels(contrast resolution), then the minimum brightness levels is 256.

Screen display[17]. Viewing electronic images on a screen are referred to as soft viewing. This is because there is no hard copy image as of yet. Images viewing this way contain 72 dots per inch.

Scratch Disk[18] Many image processing programs require that a copy of the image being processed be held in temporary storage so that operator errors can be undone. Because of the size of images, the copy is usually held in reserved areas of the computer referred to as the hard disk. Programs such as PhotoShop will require you to identify a scratch disk with proper memory allocation.

Steps in the image making process might be listed as a CHAIN or sequence of steps

subject Ł light/energy Ł reflectionŁ lens Ł exposure Ł CCD Ł record Ł store Ł move Ł save Ł processŁ save Ł read Ł archive

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15 Zigon, T Focal Encyclopedia of Photography Focal Press1993 ISBN 0-240-80059-1

16 R Kraus l Focal Encyclopedia of Photography Focal Press1993 ISBN 0-240-80059-1

17 J Larish Focal Encyclopedia of Photography Focal Press1993 ISBN 0-240-80059-

18 R Kraus Focal Encyclopedia of Photography Focal Press1993 ISBN 0-240-80059-

Images and using them
Choosing the right digital camera and associated computer hardware is entirely dependent on the projected role the photography will play in the office, clinic or research lab. Possible uses for images within the dermatology community include, but are not limited to: documenting skin exam findings, following nevi longitudinally for change, embedding the image in consultation letters, creating slides for lectures that include digital images, research applications as well as other situational uses, such as for web display. As a consequence, how quickly images are captured in the camera and transferred to storage, display and print devices determines the usability and practicality of the system for the particular purpose. Office based uses, such as documentation of the patient exam finding, require quick, error free operability. On the other hand, shooting a few high quality images of a prepared microscope slide, intended for publication can be performed in a more relaxed and less time sensitive manner.
Counterbalancing the need for a reliable, efficient office based system is the need for images which accurately reflect the exam findings. Camera resolution and color accuracy must be of high enough quality to faithfully render what is seen on the patient exam. Minimum standards for digital imaging and display have been studied in the medical environment. Perednia [i] demonstrated that there was no significant difference in the useful information delivery between digital images (574 x 489 x 24 resolution) and slide images. Bittorf et al [ii] in a side-by-side comparison using projected slides demonstrated that 768 x 512 x 24 resolution is sufficient for viewing dermatology images. A minimum requirement of 768 x 512 pixel resolution is significantly less resolution than is found in many of the low-cost digital cameras available today.

How much resolution is enough? Once again, the final use of the digital image will determine how much resolution is really required for the particular system. Printing images requires more data to obtain high quality prints. Displaying images on screen requires less data than image that will be printed. The standard computer monitor sold today is typically using a 1024x768 pixel resolution at 72 DPI (dots per inch) while a quality print requires 300 DPI. If 5 x 7 inch prints are required, this translates to a 1500 by 2100 pixel resolution image (5 x 300 = 1500 by 7 x 300 = 2100). Conversely if a web site were being authored using a monitor resolution of 72 dpi, then for the same 5 x 7 inch image would only require 360 pixels x 504 pixels (5x72=360 and 7x72=504K).

Within digital photography there are many relationships. Images that are highly resolved will require considerable computer power in "processing" digital images, while images that are lower in resolution will require less computer processing. Computer processing speed is indicated by the main computer chip or CPU (central processing unit) number of the computer. In the IBM compatible world, affordable personal computers now typically contain Intel Pentium II or III generation chips (or compatibles) and are listed at 900 mhz or greater. Apple computers, using the PowerPC G4 chip exhibit similar if not greater "clock" speeds. If one is using a high resolution digital camera and capturing many images of multiple atypical nevi in a given patient, one will need to consider how a higher resolution both effects storage requirements (hard drive and back-up media) and viewing of these images (opening when the patient returns for their follow-up visit. Some of the "low-end" consumer digital cameras are now capturing images using megapixel chips. Taking ten images of a patient with atypical nevi would not be unreasonable, however 20 megabytes of media storage or hard drive storage will be required for each visit if the image is not compressed. Compression is a technique allowing an image to be stored and saved as a smaller file, thus saving storage space. Compression is accomplished through image processing software, which is built into the memory of most digital cameras. In a compression scheme, there can be lossless or compression with some loss. In either case, pixels that are adjacent to one another and identical in information are interpreted as one value, which thereby shrinks the amount of data the file contains. This is of course influences the amount of hard disk space each would image require, and then this will be influenced the type file, as well as the size of the files that a camera exports. Big files will move slowly, as compared to smaller files, which will be quicker to move anywhere. Additionally how the images will be displayed influences the image processing considerations that are required. The use of video projector for display or the creation of a poster will influence the resolution and processing. These are but a few of the many issues that will be described below.

Scanning film to create digital files
Before analyzing digital cameras and approaches, it should to be considered, that the creation of a digital image to be achieved in several ways. One of the easiest methods is by scanning existing 35mm film images. Through either purchasing a scanner directly or using scanning services offered through the checking off and returning the scanned image services box on the or photo-pouch/mailer at the local pharmacy for example. Devotees can purchase a moderately priced film scanner for home or office use. The major photofinishers such as Kodak and Fuji have easy to use systems where your negative or slide film can be digitized and returned to you on CD-ROM or diskette . There are countless other local providers of such services and can easily be identified through professional photography sources. Kodak also offers a service described as Photo CD which is a completely different product than a simple scan and CD-ROM. This will be further discussed later in the article.

The adoption of a scanner might be cheaper in the short run rather than purchasing a camera. Currently, an adequate desktop scanner can be purchased for $250. These digital files can be quickly be enhanced as necessary with an image processing software such as PhotoShop®. Current scanners and their software interface will allow features such as cropping, brightness or contrast changes to be pre-set so to minimize the image processing time which always takes time. There really is nothing immediate about electronic photography. A scanner that is capable of working quickly with resolution of at least 300 dots per inch, an absolute requirement where applications for printing will be desired. Other features might include a 35mm slide caddy for scanning multiple slides, a fast through put(read-write-time) as well a useful color response.

Video to Digital methods Another method to create digital images easily is accomplished with the use of video capture and a computer outfitted with a video capture board. The simplicity of this approach makes it highly desirable**.** The live image can be observed for cropping and lighting concerns. The down side to the simplicity is that the digital image created is often of lower digital resolution than other methods. The video signal is sent directly into the computer and with a video capture board, one frame of video can be captured as a still image. A special board is required when using this method and can be purchased for as low as $500. VHS, SVHS as well as digital video formats as input is acceptable. Typically the resolution is low and is approximately 640 pixels x 460 x 24 which will create approximately a 1mB file. The approach is very convenient for the above listed reasons and small images are usable but may if printing is required be less satisfactory than Polaroid prints. If color prints larger than 4 inches x 5 inches are required, this method will be highly inadequate. Pictures will not have sufficient data (resolution) to be enlarged much beyond this size

Cameras and Photography Equipment
At the time of the writing of this article(July 1999), no less than 100 digital cameras were available at a selling price of $1000 or less. This statistic is quite remarkable considering that this type of digital camera has only been available for a period of 3 -4 years. All cameras, independent of "capture technology" can be classified into families. These classifications include traditional SLR cameras which are designed to the use of interchangeable lenses or range finder type cameras where the image that camera viewfinder produces is not the image that the camera lens records. Within these two classifications of camera type, there are various models and features. As with all types of cameras, there are many different levels of quality. Point and shoot cameras(many range finder type cameras) for example, might have a variable focal length lens(zoom) or a fixed focal length. They might have auto exposure features or fixed shutter speeds. The features found on the camera will influence the cost. The higher the cost, the greater the features. Because of the endless manufacturers of these products, the general features are most important to become familiar with.

At present, inexpensive digital cameras($500- $1000) can be classified primarily as point and shoot cameras, but are quickly evolving into the more sophisticated SLR types. Next year at this time, the authors are certain that many of the sophisticated features found on the professional level SLR digital cameras will migrate into the less expensive cameras. All of these cameras, SLR or point and shoot, will use an area array "type" CCD. Rather than having film behind the lens, a digital camera will utilize a CCD to capture the various focused, light reflected from the subject. The CCD is a detector and it has a vertical and horizontal pixel array which defines its resolution. The greater the number of pixels, the greater the amount detail that will be discriminated. Compared to a film technology which uses silver grains to resolve detail, digital cameras have very finite resolution potentials determined by the number of pixels. The physical dimensions of the chip coupled with the number of pixels on the chip determine its resolution. A small chip might contain as few as 640 pixels in the horizontal dimension and 480 pixels in the vertical dimension. An example of such a camera would be the Apple Quick Take, while the highest resolution the market boasts a image resolution of 2000 x 3000 pixels. This chip can currently be found in the Kodak DCS 660 which is a very sophisticated SLR camera(originally manufactured by Nikon).

Many intermediate resolution cameras have a chip resolution of approximately of 1000 x 1500 and might be referred to as a megapixel chips. There are too many cameras in this category of resolution to list. In a very recent issue of a well respected electronic imaging magazine Herb Paytner[19] used a new term to characterize these cameras, pro-sumer models.(Not professional and not consumer/amateur). What is most important to

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[19] Herb Paytner, "Professional Applications for Prosumer Digital Cameras, Photo>Electronic IMAging Vol 42. No 8 August 1999

determine before purchase is whether the resolution is real or interpolated by the cameras software . As you will recall, interpolation is image processing where pixel data is created via software. Real optical resolution will always be superior to interpolated data. It will exhibit a higher degree of image "sharpness' as compared to the algorithm produced data. A digital camera will allow a picture's resolution to be pre-set based on need and storage capacity. In this fashion, depending on the final destination of the images, lower resolution requirements may be chosen where appropriate. This will require less storage space on the camera's memory card and will allow images to be written to the camera faster.

An area array camera captures the entire image simultaneously just like a film camera. Typically, all the camera controls that would be found on a film camera will also found on the digital cameras as well others. All cameras will have some shutter speeds as well as a built in flashes. Some may have an aperture control on the lens as well as a built-in exposure measuring detectors. Many of the new releases will also integrate a LCD display on the back for previewing pictures as well as composing them. In the context of this article, it is not possible to list all the features, but rather discuss what seems practical and are the most desirable features for dermatology applications.

Chips, like film, have characteristics. These might include: ISO(sensitivity), color response(spectral) and resolution which was previously discussed. ISO describes the chip's minimum requirements for light. Current cameras exhibit sensitivities (ISO) of 80 at the low end and ranging to up 3200 at the high end. The sensitivity on some cameras can be changed and is considered variable based on lighting requirements. As the ISO is raised, less "image quality" will be available. Typically when the ISO is changed to a higher value, there often will be digital noise introduced to the image. Typically the higher the signal to noise ratio, the poorer the result that can be expected. This will present appearances of being a "grainy" image. Conversely, when the ISO is lowered, the results are superior providing there is adequate brightness to make an exposure. Chips that have a higher ISO will have advantages for example a smaller lens openings can often be used. Smaller lens opening(apertures) will deliver a better depth of field(range of focus). Additionally, there is a feature used for exposure control referred to as Exposure Value or EV. An EV of 0 produces the correct exposure, while + EV will increase exposure, making the values brighter. Using - EV will reduce exposure and create an image that is darker. This feature is quite useful when photographing dark or bright subjects. Subjects such as African Americans that are heavily pigmented can be photographed using the -1 or- 2 EV for example if proper recording of tone is important.

The CCD can only respond to differences in brightness not color. When using film, it is possible to choose from many emulsions based on project requirements. This might include daylight, tungsten or B & W type films. Conversely, CCD's must be modified to be able to respond to color. As a consequence, color separation strategies are required to create color images. Within area array cameras, the solution to the color vision problems varies. Some cameras for example have colored filters on each pixel. Through the use of software interpolation, the image is written, and the color created as a result of software and image processing. As a consequence of this method, these cameras allow photographs to made anywhere, at anytime, using a variety of light sources including the built in flash. This method of producing color is accomplished by using a mosaic technique, where in each group of four pixels, each pixel is outfitted with a different color filter. Often the filters are Red, Green, & Blue with the fourth being magenta, cyan, or yellow. Sometimes as a consequence of this phenomenon, the accuracy of color response will vary camera to camera. It should be noted that because of the way color is achieved, electronic color artifacts may be created in some images. The creation of false image color and patterns is described as aliasing. It occurs most often in areas of very high frequency patterns. A non-medical example might be vertical blinds, window screens or clothing with heavy patterns.

White balance is a valuable feature of electronic cameras and it influences the color of the image as a product of the light the image was exposed to. Since the digital camera can capture effective color using a variety light sources, the chip's response should be calibrated to the light sources that is being used with. In this fashion, there is a higher degree of accuracy to the way the color is rendered electronically. To white balance a camera, turn on the white balance feature and aim the camera at large neutral white or light gray subject that is illuminated by the principle light in the environment. By simply engaging the white balance control on the camera, the image will be encoded with the color information required to record subjects accurately and saved with each image. This activity need only be executed when different light sources or environments with multiple lighting sources are encountered. When using flash, the manual white balance feature is not required because the camera software will work automatically for that light source. All cameras will have the automatic auto balance feature. White balancing manually is usually chosen when difficult mixed lighting situations might be encountered. Within the clinical environment and with the use of the electronic flash, auto is suggested.

Interestingly , many CCD's are inherently sensitive to InfraRed. As a consequence, they are excellent for use in pigmentation studies. The camera's response to this spectrum is quite easy to achieve through by placing a Kodak Wratten #87 or #87C filter over the lens

In summary, there are many features such as auto exposure, white balance, variable ISO, and resolution that are extremely common and important. These capabilities found in the point and shoot cameras found in this price category are important but so are a few other considerations relative to how a camera is used in the clinic. Specific to dermatology applications, cameras will need to have some control as where focus is placed. Cameras must be able to get close enough to photograph small subjects such as nevi, and camera flashes need to be controllable to some extent or gross overexposure will be the result. These criteria still make the SLR camera the ideal for dermatology applications, but the price point for this type of camera is above the $1000 amount the authors have arbitrarily chosen to establish. Specifically to digital camera market, there is currently only one SLR digital camera that is priced for less than $4000, the Kodak DCS 315, while the majority of cameras are priced around $6500 and higher. It must considered that this technology, for now, has been focused into the professional photography markets

Camera Advantages /Disadvantages retailing for $1000 or less

Advantages	**Disadvantages**
resolution	not being able(in some models) to get close
immediate image previewing	controlling lighting
the image quality adjustments	achieving the correct exposure when too close
no more film /processing expenses	rate of reading /writing of the images
added benefit of being able to use	dynamic product release
digital images in office practices	not fixed focal length lens

Recommended Camera
<u>and chip features for dermatology applications retailing for $1000 or less</u>

Chip size	a minimum of 960 x 1280 pixels
Storage media	easy to access, minimum of 8mB, Camera brand dependent Addessable through the computer USB or SCSI port
Lens focal length	fixed focal length is ideal, while is variable focal length most common. Information accessible from camera as to what focal length has been selected
Various ISO settings	a minimum ISO of 200 is highly desirable Variable is very useful
Focus placement	video LCD preview with auto focus feature Manual over ride very useful
Aperture	aperture control very useful Auto works in most applications just fine, however manual over ride is excellent feature when close up
Color response	RGB is an absolute IR response has value for pigmentation studies
Min. working distance	macro capability recommended(dependent on focal length of camera
Auto/man exposure	both
Read/write	Faster is best. The camera inactivity can be frustrating when a picture needs to be made and the camera will not operate. Once an image has been recorded, slower cameras requires the photographer wait before additional pictures can be made while the image is written to the storage media. Once the system is ready, images of course can be made again.
Focus control	Auto focus with manual override and LCD preview
LCD display	2 inch minimum
Video out	NTSC useful in special applications

White balance	manual or auto
File format	variable is best JPEG in the camera or TIFF is ideal for direct to printer
Resolution	variable

Types of camera image storage media
The images that are captured in most area array cameras are written to small removable hard drives sometimes referred to as a film card. There are many names that describe these devices, however they all provide the same function. These drives may also be referred to as ATA or PCMCIA cards in the professional circles and are available in variable storage capacities. Full size cards are classified by their physical size either Type 1, 2 or 3, with the Type 3 card being the largest. Their storage capability has been continually growing since the introduction of these products. Additionally, there now exists for the point and shoot camera mini-cards referred to as Compact Flash, Smartmedia or Sony's memory sticks. Most of these cards will require a card adapter for use when the data will be transferred, often through the use of a card reader. The media cards are currently sold in a variety of storage capacities while2, 4, 8, 16 or 32mB sizes are common with larger ones on the horizon. The Sony Mavica cameras however use another storage device, the traditional floppy disk to hold images. In all contemporary cameras, files are typically saved in either JPEG, or TIFF formats. There still exist a few cameras that use proprietary file codes.

When images are captured, they are then written to these miniature devices for temporary storage and/or retrieval. Once the camera's shutter has been activated, the hard drive of the camera is activated. A term has evolved to describe this process as waking up the camera if has not been used for a few minutes. Sometimes the camera is not ready operate because the camera is talking to the hard rive. Once activated and "woken up", the camera can record an image and then write it to the media. In most cameras, there is an LED or some other type of an indicator to reference that drive is writing. Some cameras are very quick to become activated while others are quite slow. Also each camera may or may not, have the ability to photograph/record more than one image at a time. The lower end cameras can only perform one activity at a time. Activate, capture, then write to the media while the higher end cameras will be able to record multiple images before needing to write them. The image cards are removable from the camera and should never be ejected while they are being written to. The removal of a card during writing may permanently damage the card or camera or both.

Moving Images from the Camera Issue
There are many ways to move images from the card/camera to the CPU. The easiest but not always the fastest is the through the use of a serial cable. The camera is connected to the computer by a serial or parallel cable to either the modem or printer port. Various software will come with each camera which can be used to talk to the camera's files. The images can either be selected as a whole group or individual files transferred. The speed of data transfer using this type of cabling is quite slow. Image files are typically larger than text files and a serial cable which works well for printers(text documents) are really quite slow

when used with images. There are many other ways to get the images from the camera to the work station

A far faster method of image transfer involves using a SCSI device such as a card reader. Using a card reader is far more advantageous and efficient. A card reader is nothing more than a small drive designed specifically for the full size memory cards. These products vary in price and drives. These type products are readily available from any computer supply house. The drive/card can then be addressed through an image acquisition program or with a PhotoShop® Plug-in. Each camera/manufacturer will offer image transfer protocols and software. Additionally, if PhotoShop is not owned, cameras are supplied with stand alone transfer software that will have basic image processing utilities. Examples of this software include Photo Deluxe, Photo Wise, Twain drivers or Picture Easy. Most of these products provide minimal if any high end image processing potential. If a mini-card is used, e.g. smartmedia, then a card adapter will be required which allows the card to fit into the reader. These adapters are readily available and be ordered at the time the camera is purchased.

USB a newer method found both in Mac and PC's. SCSI connectors can still be found on the older power Mac's. USB is a very efficient way to talk to devices however is considered a bit slower in performance than the SCSI devices. The Mavica camera as mentioned uses floppy disk for its storage media. These of course require no accessories beyond the traditional floppy disk drive. Currently many laptops can purchased with various drive choices. A colleague just purchased a laptop with a card reader slot, a ZIP and a CD drive. The choice to stay with floppies as a media is sound as are all the products for the most part and disk storage capacity drives this.

Image transfer methods/connectors

Serial Cable	**A serial cable goes to camera & CPU**
SCSI devices	**primarily a MAC device however PC boards can be ordered - Very fast, card readers with adapters are required**
Card Readers	**typically SCSI**
USB	**PC and Mac G -3 series input ports**
Infrared	**new and not too common yet, has great potential**
Diskette	**(maybe create a little box about pcmcia)**
Fire Wire	**newest method & very fast, camera is hot wired into the CPU**

Storage and Digital Files

One important factor in designing a digital imaging system revolves around image storage and retrieval issues. The storage and accessing of digital files is a concern for all photographers. When using 35mm color slides, storage has always been achieved through the use of pages or storage cases with built in illuminators. In medicine, most departments that use photography extensively, are rightfully concerned with storage and retrieval issues. Medical images within the educational setting typically have a history of procedures and mature methods available to access the teaching libraries in specialty areas such as dermatology. Now with the ability to create and use filmless images, the how to, the where to, and the who should store the image files seems to be problematic and needs greater planning than one might imagine. An image data base is very powerful software and will be discussed in part 2 of this article. Pictures are relatively easy to make, however without a plan for naming, identifying and filing, the results can end up just like film photography leading to drawers of slides and prints, however the images reside on a hard drive and aren't physical.

This type of digital cameras is capable of generating files that are 1- to 5mB if not larger. Consequently a consideration for the system needs to be the storage media that the images will be archived on. If the hard drive space of the computer will archive a week's image or a month's images or even a year's images, then this decision will influence how to purchase equipment. Computers not so long ago were coming packaged with 40mB hard drives, while now a 5-10 Gigibyte hard drive is common. Similarly storage media has also come full circle. One popular original leader in storage media was SyQuest® produced a storage media that was capable of saving 44mB per disk. With uncompressed 5 mB files, only 8 images could be archived on this type of disk today. Compression of course is an important step that should be used when required, but the point here is that images take up much space. An extremely popular new storage media is the Zip which will hold 100mB . They have recently introduced the ZIP plus as well which is a 250mB media device. Additionally another useful product is the Jaz drive which will hold 1 or 2 gigabytes depending on which version is selected. The 2 Gig drive will accept the 1 gig media as but the 1 gig drive will not accept the 2 gig media. The standard Zip drive itself sells for less than $120 which is excellent investment because of its low price and the media retails around $10. Writable CD's are very useful product for archiving and they will hold approximately 650mB of data however require a CD Writer. This amount of expense is pennies per image, but the investment of the burner maybe $250 or higher. Storage devices are an important consideration because archiving of images will take up a lot of storage space on a computer. Producing 20 pictures, that are each 1.5mB as raw data from the camera a day can create significant storage problem over time. If this volume continues every 5 days, the storage dilemma becomes quite obvious. Within the scientific arena, there still is considerable discussion as to protocols for archiving images. Many journalists who use electronic imaging will archive a master file directly out of the camera as soon as it is transferred. Saved this way , it creates a master file for later needs and takes up the least amount of storage space without the loss of detail.

Film images have been around for over 150 years and have long term value to our society. Organizations such as the Image Permanence Institute at the Rochester Institute of Technology have done extensive testing to learn how file images should be stored to preserve them. Depending upon storage conditions, images that were created in the early stages of photography still exist today. Exposure to light, projection, dye stability, exposure to heat and humidity as well as air pollutants will all influence aspects of an image's longevity. Different issues influence electronic media longevity. A few key points need to be made here about archival and its relationship to film archives. First, film archives are quite passive. Once created they exist without much monitoring which a creates a certain attitude about them. Conversely, digital archives are always active in that they are continually being moved and converted. The media chosen and its stability will be influenced in part by, the potential for physical damage from a drive, heat, water or other environmental means. Because digital archives are migratory, they will always need to be moved to the new media of the time when that media was the standard. How archival any media remains does not seem to be a huge problem for now, however access to a working drive and reader is a much greater concern. This very concept has strong parallels to the video and cine industry across the various formats of video, NTSC, S VHS, Beta, and now digital video.

Camera Techniques and some problems specific to dermatology applications

All cameras provide a different minimum focus distance. This can be problematic if the area that is being photographed is small such as 1cm or even smaller. Clearly filling the frame is a problem with most of these camera types, however getting close enough is very important. When using cameras of this type, typically there will not be enough resolution to allow a lot of cropping to be accomplished with pictures that are not adequately magnified. Consequently, getting close enough to fill the frame and capture the data required is quite important. A macro capability provides for this. Of the cameras on the market at the time of this article, several cameras provide real macro capabilities, The Fuji MX270, the Nikon Cool Pix 950 and the Sony Mavica FD-88. With these cameras, using the LCD display rather than the viewfinder minimizes any disparity between what you see versus what the chip records. Achieving critical focus is very achievable with practice determining what the critically focused image appears like in the LCD display. In these applications, the authors suggest using the manual focusing mode.

Standardizing a normal focal length

Lenses are renown for introducing image artifacts. In that any lens can change the shape of an object, it is important to choose a focal length that minimizes this. Simply recall how people photograph in a picture when they are too close to the outside of the frame with a wide angle lens. People appear to gain weight in exactly the same way the railroad tracks appear to come together at some distant spot. This phenomena is referred to as the wide angle effect, and influenced by camera perspective. As it relates to dermatology pictures, it would be desirable to photograph with a lens that introduced no wide angle effect with the subject being placed at the lens axis. Image artifacts effect images to "appear" fore shortened or as though they were made at different image sizes. Using a standard lens has great advantages, but with zoom lens that often are not marked, this info maybe hard to determine. If the camera provides a focal length "chooser" menu, then a medium focal length for that camera is most desirable. When experimenting with the above listed cameras, for macro application, we were obligated to utilize the wide angle settings for the system to operate. This did not seem to adversely influence the pictures negatively

Choosing aperture and overriding for better control

Effective clinical photography requires as much Depth of Field(DOF) or zone of focus as possible. As can be seen, most of these cameras listed above have a very limited aperture range which then influences the image DOF. In most cases, cameras will operate with a large lens opening creating a shallower depth of field than is desirable. For dermatology applications, cameras that allow operators to choose aperture will be highly desirable. For shots that would be composed of an upper torso, an apertures of f 5.6 would be quite adequate. Clearly more aperture is better, but the power of the flash might not allow this to be realistic. When getting a picture of a nail bed as another example, f16 will have significant advantages. With cameras that allow aperture control as well as ISO adjustments, this is quite easy to access because the distant from the subject to the camera is short. Because there is quite a lot of power from the flash at this working distance, working with different ISO, aperture or power reduction will all accomplish the same goal.

More on electronic flash

To insure maximum color quality, and the easy production of accurate fidelity in the recording of dermatology pictures, electronic flash is imperative. The use of ambient light, daylight(sun), tungsten examination lights or overhead fluorescent lights will result in images of inconsistent quality, varying brightness and color. Although with white balancing features, it is possible to get good results in any light source, it might be suggested to turn off other bright sources of illumination that might "pollute" the color quality that is seen by the camera. Additionally if flash is not used, the need for long exposure times will create vibration/softness. With different light sources, there may be significant shifts in color as well. Most cameras in this arena will come with built in flash. This light source will be slightly off axis from the lens and when used at 3 - 4 feet away from a subject, it will provide very effective light. It will however reveal little if any texture but should provide useful light for color response. Creating texture light is not really practical using this type of camera. Some of these cameras however will allow a second light to be triggered through the addition of a built in synch plug in the camera body. If texture light is "really" required, then using a second side light will create texture. It will be a bit challenging to achieve the correct exposure as well as where to place the light, but with the LCD panel, these challenges should be easily overcome.

When getting close, there might be too much flash output. To remedy this problem taping a small diffusion material over the flash will work quite well. This material could be a piece of wax paper, a white plastic bag(garbage) or some similar material . This method should be used for close up applications only. Diffusing the light with longer views such as upper torso pictures, could result in poor exposures).

As can be seen, there are significant new challenges to be considered before adopting digital photography. There are however countless new products being released that enable medical practitioners to have powerful new tools available to integrate into their practices .

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