How to Incorporate Digital Technology into your Practice

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Computers continue to be one of the most important advances in the private practice environment over the last decade. At the same time, many of these technological advances are still daunting to some. The purpose of this article is to provide some practical information and ideas for incorporating digital technology into your own practice. Author’s address: San Luis Rey Equine Hospital, 4211 Holly Lane, Bonsall, CA 92003. © 2001 AAEP.

1. The Hospital Network

A network is defined as a system that transmits data between users. It includes the cables and all supporting hardware. There are two basic types of networks. A Local Area Network (LAN) is a communications network that serves users within a confined geographical area. It is made up of servers, workstations, a network operating system, and a communications link. Alternatively, a Wide Area Network (WAN) consists of the larger picture; it usually includes a connection to the Internet.

LAN

Most practices have numerous computers within their walls, and the ability to communicate between them enhances productivity. There are several options for connectivity. The simplest solution was initially introduced by Apple Computer in 1985. Called AppleTalk, it was Apple’s proprietary solution for allowing all Apple computers to exchange files via a hardwire connection. Such a simple solution is still available for Apple computers, but also for PCs, using a special connector called a crossover cable. This cable plugs into the network port on a computer and allows direct file transfer. A better and more sophisticated solution for most hospitals is to install a network system consisting of a centrally located hub, local ports, and hardwiring within the walls connecting the two. In this way, it is simple to add computers and provide access to the outside world for every computer within the LAN.

WAN

The Wide Area Network (WAN) usually translates into Internet access. There are several methods for connecting to the Internet. The one most practitioners are familiar with is a modem line. This method utilizes a phone line to make a connection to an Internet Service Provider (ISP). An individual
computer dials the phone number of the ISP to connect to the Internet. Although inexpensive and easy to establish for the practitioner, there are some limitations to this service. Firstly, using a modem will tie up a phone line while connected. In a busy practice, it may be best to establish a dedicated line that will only be used to access the Internet. Secondly, in regions with high phone traffic to the ISP, it may be difficult to establish a connection at all times. Off-peak hours, such as the evening, may provide the most reliable connection rates. Another drawback is that with a single modem line, only one computer at a time can establish a connection. Finally, and possibly most importantly, modem connections are not very fast by current standards. The top rate of data transfer is still 56 Kbps (Kilobits per second). Even with a modem card capable of this top speed, the actual connection established with the ISP may be lower.

A newer alternative to a dial-up modem, while still using existing phone lines, is called a Digital Subscriber Line (DSL). This technology arrived in the late 1990s, and it is “always on” without tying up the phone line because it transfers data at a higher frequency rate than the voice band. Also, if a hospital LAN utilizing a central hub is in place, the DSL service can be established above the hub, which means that every computer on the LAN (within the hospital) will have access to the Internet via the DSL line. The speed of the connection is linked to the distance of the hospital to the DSL provider, but the slowest DSL transfer rates are still much faster than a dial-up modem.

Other options for connecting to the outside world include coaxial cable or satellite modems. Cable is relatively new and not yet available in all places, especially more rural areas. When available, the Internet access is delivered via the same coaxial cable that provides television service. By using coaxial cable, an insulated solid or stranded wire surrounded by a solid or braided metallic shield, very high bandwidth and transfer rates can be achieved. Satellite Internet access is also new to the consumer industry and may represent a viable option for hospitals in more rural locations.

2. Practice Management Software

Most practices already have some software package in place. Some of the merits of the different systems have been discussed and reviewed at a recent AAEP meeting (Sims 1998). The main components to look for in a practice management software package include a patient record system, invoicing capabilities, and inventory management (Figs. 1, 2). Other important features are a powerful query system (allowing a search by client, patient, record number, diagnosis, referring veterinarian, etc.), easy report generation, and database backup. If the practice has an ambulatory component, then it is beneficial to have a system that will allow the practitioner to have access to the existing database with a laptop while in the field, synchroniz-
ing with the main database upon returning to the office. Finally, such features as image storage and date stamping of the record (so no future alterations can be made to the record without an annotation, establishing the digital record as a viable court document) are beneficial to the progressive practice.

3. Imaging

The imaging revolution in equine practice is being led by the invasion of digital technology. Digital imaging provides better image quality by optimizing the signal to noise ratio. It also provides improved image processing and storage capabilities. Digital imaging has transformed everything from radiology, nuclear scintigraphy, and ultrasound to endoscopy and arthroscopy.

Radiography

Although the difference between digital acquisition and post-acquisition digitization should be clear, it deserves further explanation here because some practitioners still question the clinical relevance of each.

Digital radiography means that the original image is captured in a digital format. The most common technology used in this manner is computed radiography (CR). Originally introduced by Fuji, Inc. in the early 1980s, this technology has been adopted and refined by all the major imaging companies. It involves using a screenless cassette loaded with a special x-ray stimulable phosphor plate. Once the image is on the computer, a flood of photons erases the plate, readying it for the next exposure. At this point, the image processing capabilities of the system take over. Brightness/contrast adjustments compensate for less than ideal radiographic techniques, while sharpening and edge enhancement facilities improve diagnostic potential (Figs. 3 and 4). And, of course, once the radiograph has been saved in a digital format, it can be easily archived in any number of universal formats such as *.tif or *.jpg (see 6. Image File Formats).

While CR systems have usually meant physically large readers and significant expenditures, a recent development within the field has brought mobile technology to the practitioner (Fig. 5). While still being refined at the time of this writing, a small, inexpensive reader that connects directly to a desktop or laptop computer will soon be commercially available. Such innovation will mean more widespread use of CR, including stall-side CR for the ambulatory clinician.

Post-acquisition digitization has evolved over the years due to the improvement in digital camera technology (see 4. Digital Cameras). While flatbed scanning can still produce high quality images, top-of-the-line transparency scanners are expensive and the process is time consuming. With the advent of the inexpensive megapixel and multimegapixel digital cameras, digitization of a radiograph while still on the viewbox has never been easier. Using a good quality digital camera in such a manner will provide images for presentations, client viewing, archiving and printing reports.
It should be noted that the legal ramifications of digital radiography versus post-acquisition digitization of radiographs are very different. Although to this author’s knowledge there has been no legal challenge of digital radiography within the human or veterinary fields, the American College of Radiologists have adopted guidelines for its member physicians entitled the “ACR Standard For Digital Image Data Management” (available at www.acr.org). Within this manuscript both digital radiography and post-acquisition digitization of radiographs are discussed. Digital radiography systems and dedicated film scanners for post-acquisition digitization are considered acceptable because they meet the resolution requirements and stamp the image with the appropriate data to make it a legal document. Although these same standards should apply to veterinary medicine, the only
real challenge will probably pertain to the pre-purchase examination. In such a scenario, post-acquisition digitization of radiographs, especially if done with a low-tech system such as a digital camera, will not be likely to stand up in a court of law. Similarly, it would not be feasible to expect another veterinarian to render an official opinion based on such images. However, as stated in the preceding paragraph, post-acquisition digitization, even when carried out with a digital camera, will provide many practitioners with the digital edge they desire.

Nuclear Scintigraphy

Recently, several companies have developed nuclear scintigraphy software that runs on desktop computers instead of the dedicated computers of the original equipment. The first system commercially available to the equine industry ran exclusively on a Macintosh, but subsequent systems have been developed for the PC and Unix computers. Most desktop versions of nuclear scintigraphy software simply take the x, y, and z signal leads directly from the gamma camera and run them through a digitizing board either positioned internally on the motherboard of the computer or externally via some kind of bus setup. Digitizing the signal from the gamma camera means that the x and y coordinates are used to create dots, or pixels, within the image and the z component of the signal is used to determine how intense the signal will appear at each pixel. The beauty of most of these software systems is that once the signal is digitized, a host of imaging processing can be employed to increase diagnostic potential. There are several aspects of a software system that can improve diagnostic capabilities. Some of these are the color model, region of interest, filtering, and motion correction.

Color Model

The original dedicated computer systems only offered pixels in the basic black and white. Through the z component of the signal, the computer assigns a shade of black, white, or gray to each pixel, depending on the intensity of the signal. The look-up table is the mathematical method the computer actually assigns each pixel within the image an absolute shade. The human eye can see more colors than shades of gray, and for this reason, certain color look-up tables may be more sensitive at defining the difference between regions of mild to moderately different pixel values. However, each software system will have its own look-up tables and some will be more sensitive than others. In fact, some look-up tables will actually create artificial ‘noise’ within the image, obliterating normal anatomical features of the image and obscuring focal increases in radiopharmaceutical uptake. For this reason, it is important that the operator sample each look-up table available to them on images with known lesions to determine the best one for their system (Figs. 6–8). In addition, the author sometimes finds it beneficial to change the look-up table while analyzing a study when subtle lesions are suspected or detected.

Region of Interest

The region of interest facility allows the imager to mathematically compare pixel values from one aspect of the image to those from a comparable region. Such a capability works by allowing the operator to freehand draw or use the Autoshape function to generate a circle or polygon over a region of the image. Using simple mathematical computations, the software totals the pixel values for that region, generates means and medians and compares it to the values of a similar region via a ratio. In
this way, subtle differences can be detected or diagnostic comparisons can be made.

Filtering

Filtering is a tool commonly employed by commercial image processing programs and adapted by some nuclear scintigraphy software. It is a very simple concept that works at the level of the pixels to more clearly highlight subtle hotspots. The software analyzes the pixels in the image and averages the values for a specified group of pixels. In this way, slight alterations in pixel shades can seem to become more intense and outline an abnormality.

Motion Correction

A relatively new innovation to nuclear scintigraphy software has been the addition of motion correction capabilities (Figs. 9 and 10). Several European companies pioneered this idea in the early 1990s and the first system became available in the United States late last year. The main reason such a capability has been so long in the making is that it is strictly a veterinary innovation and not necessary in the human imaging field. Obviously, when dealing with tranquilized horses, some slight movement of the subject may always be present. In order to understand how this may adversely affect the image, it is important to remember how the computer normally generates the image. In a dynamic acquisition, each image is obtained for a brief time period, such as 1 sec, and multiple images are independently acquired over a certain time frame, such as 2 min. Therefore, in this example, 120 independent images would be acquired over the 2-min time frame. Movement is not an issue in such a situation because it is not likely to occur over a 1-sec acquisition and because each image is independent of the next. In a static acquisition, however, the image is ‘updated’ over a specified time period. Updating means that additional pixels are added to the image every 1 to 10 sec, for instance. If the subject has moved between updating episodes, albeit minutely, the outline of pixel values may be different. Hence, a focal and intense hotspot may become larger and less intense or may even blend into the background of the image, entirely obliterating it from diagnostic consideration. The basic concept behind motion correction is that each period of updating is treated as an independent acquisition and at the end of the acquisition period all the independent images are aligned to produce one very sharp image. This is usually accomplished in one of two ways, either manually or automatically. Motion correction is particularly useful for imaging the spine, pelvis and upper limbs, but may be useful for all the images.

Ultrasound

In the case of the digital ultrasound system, the analog signal that comes from the transducer is digitized immediately upon entering the ultrasound console. All of the image processing and manipulation is done in the digital domain.

Digitizing the signals this early in the imaging process permits the system to accomplish several important functions. The first is that the digital image quality is locked in at the beginning of the imaging process. The earlier the signal is locked in, the more likely the signal integrity will be maintained, resulting in sharper images. Another is that the digital time delays permit much greater precision in the shaping of the ultrasound beam. Because these time delays and summations are all done digitally, they do not require the frequent calibration associated with analogue beamformers. Finally, the digital beamformer permits the system...
considerable flexibility in reprogramming the size, shape, direction, and intensity of the beam. This, in turn, allows for more opportunities to implement future image formation enhancements leading to better diagnostics.

**Digital Enhancements in Ultrasound**

One such digital enhancement has been introduced by Siemans, Inc. It is exclusive technology known as Siescape™ (Fig. 11). It works by assembling thousands of separate digital ultrasound images as they are received by the transducer. A sophisticated algorithm designed for pixel recognition is used to compare and sequentially align the images in their correct anatomical position. This results in a panoramic image on screen in real time. The technique has recently revolutionized some of the imaging procedures used on equine limbs and small animal abdomens.

**Arthroscopy/Endoscopy**

These two diagnostic modalities rely on visualization of a body cavity with a scope. For years they have been performed using a camera linked to a television monitor for ease of viewing. A video cassette recorder is used to record the analog signal that is output from the television. The videotape can then be used as part of the client’s record. Advancements in technology mean that some of this visualization equipment will produce digital images directly, bypassing the need to enter the analog realm at all. Alternatively, digital video cameras are now available that will digitize the analog signal that is generated directly from the camera (Fig. 12).

### 4. Digital Cameras

Another recent advance in clinical technology has been the addition of the digital camera. It is a convenient and practical way to establish a digital

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**Fig. 11.** This is an example of Siescape™ technology. The reconstructed digital ultrasound image very clearly illustrates the fractured right ilium in the pelvis of a racehorse (small white arrow).

**Fig. 12.** This is an arthroscopic image of a septic tibiotarsal joint. The image was taken from a digitized clip of video and can be printed for the owner or archived in the record.
record of clinical case material or to engage in a simple form of ‘telemedicine.’ The technology has experienced significant improvements over the last several years since its introduction to the general market in 1995. At that time, the fact that only one company produced such a digital device made the purchasing decision rather easy. Now, most major computer and camera companies manufacture at least one model, requiring a more thorough knowledge of the key components. The main ones include picture resolution, power source, and ease of image transfer to the computer. Other features that may be of importance to the equine veterinarian include printing capabilities, file type, viewfinder, zoom capabilities, exposure settings, and price.

Main Features
The resolution of the photograph, like other digital images, is registered in pixels. Traditionally, the pixel values for digital cameras were listed as dimensions, such as $640 \times 480$ or $1280 \times 960$. More recently, it has become popular to record the total number of pixels captured within the image, a number obtained by multiplying the number of horizontal pixels by the number of vertical ones. Thus, a camera shooting at a resolution of $1280 \times 960$ would generate 1,228,800 pixels within the image, also known as a 1.2 megapixel camera. A multi-megapixel camera is capable of generating over 2 million pixels within the image, resulting in a professional quality image. The resolution required by the veterinary photographer should be governed by the proposed use of the pictures. For those intending only to archive and view the pictures on the computer screen, a low-end camera shooting at $640 \times 480$ is sufficient, whereas if a printer or publication is the endpoint, a higher resolution should be sought. The professional quality cameras would rarely be needed in the veterinary situation and their purchase would be at the discretion of the buyer.

The mode of power required by the camera may become an issue to mobile equine practitioners. Some cameras require battery power exclusively, whereas others have an optional AC adapter that can be used. Standard alkaline batteries will seldom power a camera for very long, especially if a power-hungry option, such as a liquid crystal display (LCD) viewer or viewfinder, is used frequently. Rechargeable Nickel Cadmium (NiCd) or Nickel Metal Hydride (NiMH) batteries are becoming common due to the extended charge life they offer. If rechargeable batteries are chosen, it may be beneficial to purchase a second set so there is always a charged set ready to go.

The ease of image storage and transfer to the computer may be important to the consumer. The original cameras required a ‘hard wire’ connection to a computer running the native camera software in order to download the pictures. Although this method is still available in some cameras, more recent innovations include saving the acquired images to a universal 3.5-in. disk or to a removable memory card requiring some kind of docking device. Cards routinely come in sizes ranging from 2 MB to 48 MB, with larger capacity cards being developed all the time. The number of images that will fit on a storage device varies with each camera and chosen image resolution or file format. For example, a 2 MB card for some models may hold 13 images in “fine” mode, twice as many in “normal” mode, and almost 4 times as many in “economy” mode.

Other Features
Ease of printing the photographs may be an issue for those veterinarians wanting to generate quick client reports. Many cameras are able to print directly to a peripheral device while some still require downloading to a computer before printing. The type of image file the digital camera generates usually varies from generic to specific. JPEG has become the industry standard for many cameras due to its high compression ratios and resultant small files, while TIFF is often the choice for uncompressed images. (See 6. Image File Formats for a more complete explanation of these image files.) It is probably best to avoid dedicated file formats requiring vendor software to read, unless a reasonable level of computer competency is present. Zoom and close-up capabilities are critical to the veterinarian desiring to capture detail in their photographs. Optical zoom is preferred because it is ‘true’ zoom while digital zoom interpolates, or ‘creates,’ pixels to artificially add more detail to an image. The former feature should not be confused with an optical viewfinder, which functions similar to a film camera’s viewfinder, in contrast to an LCD viewfinder, which allows the photographer to see on a small screen exactly what will be captured in the photograph. Many cameras are equipped with both features, probably a good thing for the equine photographer, because the LCD viewfinders are convenient yet power-hungry on batteries. Ancillary to the LCD viewfinder is the ‘playback’ mode that allows the operator to check each photograph before downloading it to a computer. This could be a very handy feature for veterinarians who are photographing in the field and downloading back at the office. Some of the traditional photographic settings found on film cameras such as exposure, shutter speed, and ISO have been automated in digital cameras, although serious photographers may desire manual control over these options. The ISO number is a measure of how sensitive the camera is to light. A higher number means the camera can successfully capture images with less light. Finally, price could be a limiting factor for the equine veterinarian and the market varies tremendously based on how many of the above options are chosen. As with most new technology, however, one trend is clear. The price has continually fallen since the introduction of the digital camera over 5 years ago and it should continue to do so in the future.
5. Digital Video Cameras

Built on technology similar to that of the digital still camera, digital video cameras are also becoming more popular. Although the price has dropped for these items as well, they remain more expensive than digital still cameras because the acquisition process is more complicated. Like the digital still, digital video cameras use a charge-coupled-device (CCD) to generate a picture. However, unlike the digital still camera, each ‘picture’ is only one frame of the video clip, which means the CCD must be capable of constantly recharging so that the American video standard (NTSC) of 25 frames per second can be generated. All this action is orchestrated by the processor within the video camera (Fig. 13).

6. Image File Formats

There are many file formats that are used for images, but some are more useful and universally acceptable than others. They are TIFF, JPEG, BMP, PICT, and EPS.

**TIFF (Tagged Image File Format)**—this is a machine and system independent image standard meaning it can be used on a Macintosh or PC. For this reason it is a good choice for scientific applications and quantitative analysis. These files include the suffix *.tif.

**JPEG (Joint Photographic Expert Group)**—this graphic file format is created by this group of expert photographers from 2 international bodies. One of the notable aspects of this format is the high compression ratios that can be achieved without image degradation. Although JPEG employs lossless compression, it does so by utilizing an existing property of human vision where minute changes in color are less noticeable than changes in brightness. Compression ratios can reach 10:1 or 20:1. It is also a good choice for compatibility between Macintosh and PC. The suffix for these files is *.jpg.

**BMP (Bitmap)**—this is a file format that is most commonly used in many PC applications, especially within the Windows operating system. Files created within these applications will automatically display the *.bmp suffix.

**PICT (picture format)**—this graphic file format is native to the Macintosh system. It is an object-oriented graphic format that relies more on the color of each pixel than on the actual pixel value. Images are usually tagged with *.pct.

**EPS (Encapsulated PostScript)**—this is a standard format for drawing, image, or complete page layout, allowing it to be placed in other documents. Exclusive to this file format, the header contains a low resolution preview of the file. The file suffix is *.eps.

7. Practice Websites

With all the consumer traffic on the World Wide Web over the last several years, developing a practice website is a good way to disseminate important information to clients. Most ISPs include web space as part of the membership services. Unfortunately, the website address or universal resource locator (URL) must usually contain part of the ISP’s name before listing your personal name. Also, the
web space may be limited to a certain number of pages, amount of space, or even by the number of hits that can be accommodated during a specified time period. Alternatively, it may be beneficial to come up with your own practice domain name to register. Simply visit the website for Network Solutions (http://www.networksolutions.com) and search to see if your chosen domain name is available. If it is, you can register the name for $35 per year. Once the domain name is registered, you can contract with an internet company to host the website for a fee. In this way, the website address or URL will be 'www.yourpracticename.com,' making it easy for clients to find it. Also included with most internet package deals are a specified number of e-mail addresses @yourpracticename.com. Again, this simplifies the process and allows clients easy access to your e-mail accounts. For instance, our practice name is San Luis Rey Equine Hospital, so we opted to shorten the domain name to SLREH or www.slreh.com. Our e-mail addresses are martineelli@slreh.com, grant@slreh.com, and so on, with a general account slreh@slreh.com for our secretary to check.

Designing a Website
The practice website can be designed by a professional or you can do it yourself. There are numerous software packages available to aid in website construction. Topics to cover on a website may include some of the following (Fig. 14):

- Hospital name, address, phone number, fax number and e-mail address
- A mission statement
- A description of your facilities and what services you offer
- A list of staff members, including consultants
- How to make an appointment and directions to the hospital
- A list of appropriate links

8. Conclusion
The computer has revolutionized industry and society over the last 5–10 years, so there is no reason to think it can’t do the same for veterinary medicine. Much of what can be done in a practice setting simply takes some initiative and imagination. From there, the sky is the limit. Have fun, and be productive!

Footnotes
aSneakers Software, Inc., Sausalito, CA.
bIDEXX, Inc., Westbrook, ME.
cHermes™, Nuclear Diagnostics, Hägersten, Sweden.
dSiescape™, Siemens, Inc., Bayern, Germany.