Digital Imaging For TEM
Part 2 - Pro's & Con's

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Part 1 of this series, in the August '94 issue of this newsletter, contained an overview of digital imaging for TEM. The key point was that digital imaging systems are getting better and costing less. This article contains a brief summary of the pro's and con's of digital imaging for TEM.

Although different laboratories have different situations, there are common issues that all can consider when evaluating the value of a digital imaging system for TEM.

Information Density: As things stand today, a typical 1024 pixel by 1024 pixel digital imaging system cannot compare with film! Typical film used for EM can display feature sizes as small as 10 µm. This is like having a film negative made up of 10,400 pixels by 7,800 pixels. Put this way it's tough to see how a factor of between 7 and 10 can be ignored.

This may prompt you to ask why so many people are paying to add a seemingly inferior imaging system to their instruments? Well, one common answer is that users believe they usually do not use all the information offered by film. They feel that, on many occasions, when they press that "photo" button and expose a negative, they are paying a high price (to the film industry) for information that they do not generally use and cannot standardly perceive. At the same time, they are missing the benefits of digital imaging.

Cost Benefit: There may also be cost benefits to reducing darkroom operations. Although the results of darkroom work are excellent, the process is time consuming, labor intensive and environmentally stressing. Cost benefits can be estimated by calculating the cost of current operation and comparing that against the cost of purchase and operation of a digital imaging system. The current costs include darkroom materials, labor costs and the cost of chemical disposal, plus "overhead" charges for occupied space. The cost per print will vary greatly but costs per darkroom print of $3 to $6 are very common. By way of comparison, digital imaging systems can produce very high quality prints using techniques such as dry film processing for less than 50 cents a print.

Ease of Operation: The traditional "slow scan" CCD system is operated as an electronic "still" camera. Newer digital imaging systems use CCD cameras with faster and variable frame rates. This means that the operator can use faster "live time" frame rates for live imaging of the sample and then switch to slower "slow scan" frame rates for image capture. This means that, with a little practice, you can do a lot of work directly from the computer monitor.

Low Dose Operation: Digital imaging systems have very high sensitivity. It is not uncommon to have a very acceptable digital image using beam currents as low as 1 to 5 pA per square cm. This is much less than is required for viewing directly on the TEM's viewing screen or through the binoculars and is less than the normal exposure of standard sheet film. A digital imaging system allows delicate samples to be studied longer and at higher magnifications.

On-Screen Image Processing: When an image is captured it resides on the image plane of the digital imaging system. It can immediately be adjusted by both simple and complex algorithms. Gray scale functions such as the image contrast and brightness can be adjusted and immediately evaluated.

On-Screen Conferencing: A digital imaging system displays images on a computer monitor. Users can point and discuss features on the monitor screen. They don't have to take turns peering through the TEM's binoculars. They can agree or disagree, but the important thing is that they can be sure they are communicating clearly.

Extensive Image Annotation: Annotation allows text and graphics to be added to an image. This can "burn-in" critical information such as a patients name, case number, section number and date. Other generally useful items such as a scale marker can also be added.

Immediate Hard Copy: It is frustrating to spend even 30 minutes waiting for darkroom techniques to provide hard copy of data in situations where patient health is an issue. With a digital imaging system a hard copy can be produced at the click of a mouse. Data can also be transmitted to remote sites.

Off Scope Image Processing and Analysis: If you have saved an image as a standard data file, you can process it using any computer that holds a copy of the processing and analysis programs. If you have bought specialized analysis software, you may have to purchase additional copies for "Off Scope" procesing and analysis. Image processing software packages, such as NIH Image, are shareware. Image archiving software is available for about $100.

Image Archiving: Many institutions have rooms set aside for image archives. Negatives are sometimes stored under "archival conditions" to ensure minimum image degradation. Some archives are in vaults to protect against fire or flood. Archives have carefully regulated indexes so that records are accurate and accessible. The expense can be tremendous. Digital imaging systems can be used to store images in a non-degradable format. Multiple archives can be created, linked, networked and monitored at a fraction of the cost required using traditional methods.

Database Management: If information is power, a database is the ignition switch. Modern data bases allow you to search massive image archives selecting images with common factors. Operators can use key word group images and then display them in batches.

Image Analysis: Detailed image analysis packages can be applied either during analysis or on any computer having sufficient RAM to accept images.

Data Networking: Data Networking can change the way we work. With a digital imaging system you can interact with clients from an extended geographical area via network communications. This might simply increase your customer base, it might allow you to offer more specialized services to a larger community or it may simply allow your current customers to get faster service without the requirement that they travel to your facilities.

On-Line Teaching: Many laboratories have purchased a TV rate camera system for teaching purposes. Although these systems have no image storage or printout capabilities, they are able to allow general viewing. Nevertheless, with a new digital imaging system you can do much more. Students can observe a live image on the computer monitor. You can recall key slides from your data base, you can archive images during class for future assignments, you can process and analyze images as students watch and you can monitor exactly how students operate the system.

Reduced Waste Disposal: We are all aware that environmentally conscious practices matter. They can also be cost effective. Put simply, the cost of chemical disposal is rapidly increasing and it will only get higher. Darkroom chemicals are particularly expensive to dispose of. Anything to reduce the volume of such waste will benefit the environment and budget.

Improved Vacuum: Vacuum science teaches us that the efficiency of pump-down depends upon the degree to which our system is free from water vapor. Sheet film is a massive reservoir for water vapor. If a TEM can be run without introducing sheet film, sample contamination will decrease. Beyond this, if instruments can be designed without the need for film, vacuum systems could be radically improved.

Proof of Practice and Protocols: If you are involved in clinical investigations or litigation the results of your analysis will be questioned. Often the contentious issue is exactly how you obtained the data. With a live scan digital imaging system based on a PC or Macintosh, standard video boards can be used to record everything appearing on the digital imaging systems computer monitor. With the addition of audio input, it is trivial to produce a complete record of an analysis. You can document your work clearly and completely.

Color Images: It is possible to present images using "pseudo-color" rather than monochrome. The results are striking. Nevertheless, it is not clear that "pseudo-color" representations add much to image interpretation, though they may be useful for teaching and display purposes. ■