SWAPPING ATOMS FOR BITS: MANAGING THE DIGITAL EVOLUTION IN THE MICROSCOPY LABORATORY

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Microscopy labs have very quickly moved from keeping track of and storing thousands of samples and negatives "atoms," to having to now deal with the same number of samples, and a few negatives, but in addition, we may now have thousands of digital images "bits." In a two-year microscopy teaching program, which includes 18 microscopy courses, there are thousands of images, which must be collected from a variety of input devices running on various platforms. These must then be associated with different types of data files that need to be tagged to reports as well as being tagged to projects and courses. All of this information must be accessible, first to all those involved with doing the project, as well as to anyone associated with needing the results. Some of these systems use film and digital imaging, while others rely entirely on digital transfer. Tracking progress and security issues are also important. In our case, it is also necessary that all of this require minimum staff time. Thus, it was necessary to set up an image database that is really an asset management system. Also of prime importance is how to train all those involved in digital methodologies and ethics.

The number of image acquisition systems as well as how the images are to be used determined the choice of which asset management system we selected. The database that met all of our needs and that was tailored to microscopy was Quartz PCI TM by Quartz Imaging Corp (Distributed in the US by Hitachi, Nissei Sangyo America, Ltd., Pleasanton, CA; http://www.nissei.com). Because of the size of our database, the number of people accessing it, and the need for security, we require the capabilities of the client/server Enterprise version of the Database, utilizing a web browser interface. In our facility, the same images often have to be accessed by several users for group projects. The ability was needed to track the images not only with other data (e.g. spectra) and reports but also by several criteria e.g. course, project, sample number, type, client number, etc. Our image acquisition systems are operating on Macintosh, PC, and Unix® platforms. Our digital imaging systems include Transmission Electron Microscopes (TEMs), Scanning Electron Microscopes (SEMs), Light Microscopes (Stereo, SLM or Compound, CLM), Focused Ion Beam (FIB), Atomic Force Microscope (AFM), Flat Bed Scanners (FBS), Negative Scanners (NS), Video Cameras (VC), and Digital Cameras (DC). Because we look at a great variety of sample types with all types of microscopy, images are made available for teaching purposes inside as well as outside our institution. For that purpose, the images are available in a compressed format, and available to researchers in the original high-resolution format. At the same time, security was necessary with respect to who can access research images. To maximize equipment use time, another consideration is that a minimum of typing for entering information be required, so we use browse lists for most fields. The images are also available from computers outside the lab in order to free up lab equipment. Figure 1 indicates the flow of images from the image acquisition system to the database and then availability from the internet or internally.

The underlying database engine being used is Microsoft® SQL ServerTM. Adding images to the database and searching for images is done either through platform-independent, web-based software or through PCI Client software that uses Windows 2000®. Windows 2000 Server is being used for both the database server and the client software. The PCI database software consists of 3 parts: the PCI Intranet Image Server, which gives web access to the database; the PCI Acquisition Software, that goes on each image acquisition system; and the PCI Client Workstation software, which is used to change or modify the database. For Internet use, a web browser e.g. Netscape Communicator® or Microsoft® Internet Explorer is also required. For security, passwords are added to the system.

Our hardware consists of a Dual Pentium-III 500MHz LANServer with 1 TB of hard drive arrays with built-in RAID 5, which can be easily upgraded to 2.3 TB without a major reconfiguration and scaleable to multiple TBs The arrays are built with 73 GB LVD drives at 10,000 rpm (Corporate Systems Center, Santa Clara, CA; http://www.corpsys.com). A Cybernetics Tape Library system with Retrospect software is being used for automatic back-ups. The hardware system thus consists of a main server, a PowerFile CD/DVD jukebox, CD/DVD archives and a back-up tape system. User defined fields are established based on lab needs. Many microscopy- oriented fields already exist on the initial "off the shelf" database version, but others are added as required. Fields can be made mandatory or non-mandatory. As each image is acquired, to be saved, the user MUST fill in the mandatory fields. Point-and-click browse lists are used whenever possible for ease of use, and accuracy of data. The images are accessed via either the PCI software or through any web browser from the Internet.

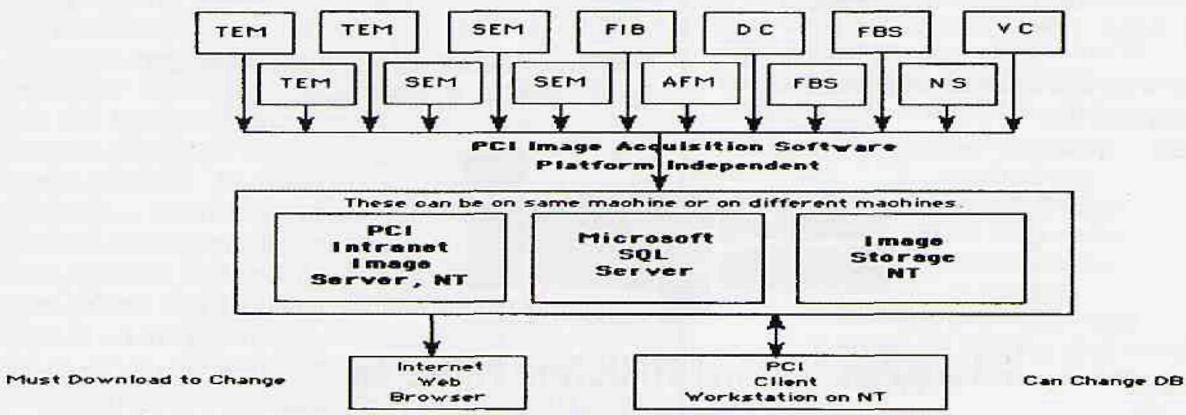

Fig. 1: PCI Image Management System at San Joaquin Delta College, MTC


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In our case the server needs to hold 1 semester's worth of images (from 9 microscopy courses). At intervals (e.g. at the end of each semester), the images are taken off the server and downloaded to DVDs in the juke box, which still provides active image access. Thus, the images for two semesters (1 year) are actively available at all times. Many of our projects span over 2 semesters and some long-term projects span several years. The images not needed for active retrieval would then be downloaded to storage DVDs and archived. The database keeps the thumbnails of all the images acquired on the server at all times, but the "high resolution" images would be eventually archived when no longer needed for active use. The user would be prompted to input a particular DVD, if an archived image was needed.

Once we have built a reasonable image database, an area on the server will be made available for Internet access by a variety of colleges in our area and local grammar and high schools. The database does structured searches, or unstructured searches which uses web search engine technology. The database also allows us to add images that we have collected in the past that now reside on all sorts of removable media. The combination of images should provide an excellent teaching aid and will assist in a variety of outreach programs. Image management with the use of the Quartz PCI Database has thus made possible easily categorizing and finding images, but also tracking samples, compiling reports from a variety of information including multimedia files and will make almost painless, the supplying of images to a variety of internal and external programs.

It is not too difficult to train someone how to record the images digitally and the details of a particular database once it has been set up properly. Standard Operating Procedures (SOP) are written for all the equipment. Students are required to have the lab SOP manual that is now fondly called "the big white whale" because of its size. But there is a lot more involved in integrating the digital experience throughout an entire program. If one takes even a cursory look at any booksellers' list, one can see that the books (made up of atoms) to talk about bits grows exponentially. Each version of Photoshop generates enough books to account for a forest of considerable size, especially when those versions are often updated. To minimize the atoms, but maximize the information transfer one must choose carefully what really needs to be included.

There is a fine line between the definition of a computer technologist and a microscopist but, never the less, there is a line. When conducting a training program in microscopy, one must insure that the student learns those things necessary for microscopy while incorporating the necessary computer skills. The choice of what tools are used to transfer the digital information depends on a variety of considerations. It is important that the student becomes computer literate as soon as possible. Although today's youth has been brought up on video games, career change adults and those from lower economic areas still need basic computer skills type of instruction. A core course is required in the use of computers, teaching the basics and use of a word processor, database and spreadsheet. Although an on-line course is available, many that need this type of course also need the use of the school's computers.

Beginning with the first semester's microscopy courses, oral presentations using computer generated images and data are required. By the second week of the course, students are encouraged to get a home computer or have access to one. There are several computer labs on campus available to students, however most of the report writing, etc. is usually done at night, after all the computer labs are closed. Power Point presentations are used even for the first semester students. There is still a need for teaching

certain photographic skills, especially where TEM is involved. Learning what it takes to make a picture "look good" translates directly from analog to digital. Although different procedures are used, the eye for composition, contrast, sharpness, and aesthetics are the same in both worlds. It is how we get there that is different.

To train students in the procedures of the digital world, a formal Digital Imaging for Microscopy Course is taught second semester. The challenge is to find good practical textbooks and to afford licenses to keep up on the new versions of the software. Several texts have been used over the years for lack of any single good text. Since we use Bozzola and Russell's Electron Microscopy (2nd Ed, Jones and Bartlett publishers) for our basic TEM course, we use his chapter on Image Processing and Analysis (Chapter 18) for a very brief introduction to the course. John Russ' The Image Processing Handbook (CRC Press) is used and although it is a wonderful reference, it is not an easy reading textbook. Selected readings from Chapters 1-8 are used. After evaluating several Photoshop books, the one that works the best for us is the Against the Clock Series by Prentice Hall. Either the Adobe Photoshop 6: Introduction to Digital Images or the Advanced Book in that series is used depending on the expertise of the particular student. Half of the exercises are used to give the students the basics of Photoshop. A variety of plug-ins are used with Photoshop e.g. Image Processing Tool Kit (IPTK) by Raindeer Graphics which give Photoshop a variety of scientific processing and measuring tools. The NIH Image Manual is used for doing specific quantitative projects with NIH Image. This is freeware available from http://rsb.info.nih.gov/nih-image/. For flatbed scanning, Wayne Fulton's Scantips is used which is available at www.scantips.com. The information is presented in a straightforward manner in easy to understand language. If desired, one can purchase the booklet, however the information in the booklet is available at the website. For teaching html, the Beginner'sGuide to HTML is used, which is available at http://archive.ncsa.uiuc.edu/General/Internet/www/HTMLPrimerPDF.pdf. Students are required to first make a web page using html so they understand the hypertext markup language. After they have mastered the basics, they can then use a Page Editor for making their Web Tutorials, which are required for the course.

Specific instruction in the various digital systems is incorporated into whatever course the instrumentation is used. We have PCI Quartz, SEMICAPS, Digital Micrograph, among others. As they learn how to acquire the images, they also learn the necessary software. Managing color on the computer is always a challenge for electron microscopists that have traditionally worked in black and white. Actually getting a particular printer to print out exactly what is on the screen (WYSIWYG) can be a challenge in black and white or color. Learning how to calibrate a monitor is crucial for a particular printer, but only one of the many challenges in teaching color management.

As procedures and techniques are being learned, and students begin to master digital systems, the ethics of digital imaging must be discussed. As yet, there are no real guidelines as to how much change one can do to an image without actually changing it scientifically. There have been discussions about using electronic tracks so processing is obvious. Most however don't differentiate a histogram stretch, analogous to using a lower or higher contrast photographic paper to an event such as cloning which affects the scientific content. Learning to be "scientifically responsible" is another very important piece of the digital puzzle as we go from atoms to bits in the digital evolution. ■

Media Cybernetics Opens California Branch Office

Media Cybernetics (located in Silver Spring, MD) has recently opened a branch office in San Diego, CA. This new location will provide us with more opportunities to collaborate with imaging software users in the Western United States. Contact: Kathy Hrach, 301-495-3305 ext. 260, khrach@mediacy.com

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