★ Leybold is introducing an improved stabilizer version of its highly successful **TURBOVAC 340M Magnetic Bearing Turbomolecular Pump.** This new version, which is designed to be impervious to shocks, is well-suited to the SEM market. Leybold Vacuum Products, 1-800-433-4021. MSA Conference: Booth 835.

★ A short course/workshop covering the principles of TEM specimen preparation will be offered at the Arizona State University on August 16/18, 1993. Parrticipants will gain a working knowledge and hands-on experience with preparation of specimens from semiconductors, ceramics, composites, etc. For information. contact Dr. Farhad Shaapur at (602)965-0399.

★ ASTM is publishing a new, free newsletter entitled "*ASTM Standards International.*" Covered will be information on standards development from all 131 technical committees. Contact: Ellen McGlinchey: (215)299-5400.

★ The AVS is not publishing two volumes of *The Journal of Vacuum Science and Technology* on CD-ROM: 1) Vacuum, Surfaces, and Films and 2) Microelectronics and Nanometer Structures. **Reasonable!** Contact Angela Mulligan at (212)661-9404.

★ Philips Electronic Instruments has a list of used and surplus equipment for their TEM and SEM product lines. Contact Nathan Little: (201)529-6165.

★ Hessler Technical Services is now representing KORE Technology, Cambridge, England, a manufacturer of precision engineered, custom designed analytical systems. (203)358-0266.

P.S. Should you find this newsletter of value, it would be appreciated if you would advise your salesmen. It is only through the advertising support of manufacturers and suppliers that we can continue to both improve its quality and send it to you at no charge. --- Ed.

Finger Painting or Digital Imaging

Jean-Paul Revel, CALTECH

In the good old days, when microscopists wanted to show others what they had found, they either drew by hand what they saw or hired someone to do same. Besides manual dexterity, and eye-hand coordination, drawing of course requires artistic interpretation, i.e. at least a smidgen of imagination. As a result one always had to be concerned with the objectively of rendering. Such concerns were more or less put to rest once the proper use of photography became established. The manual dexterity was reduced to twisting the focus knob, squeezing the shutter button without also shaking the camera and doing some handwaving in the dark room (artistic interpretation), surprisingly all non-trivial operations.

Today we have entered a different phase yet in the process of sharing morphological information, a phase characterized by digital recording and along with it, digital image processing. The digits now are not literally fingers anymore, but the numbers they stand for. Digital image recording and processing was originally devised to improve the quality of images returned by spacecraft and used to require highly sophisticated computing facilities. Today, however, digital image processing programs can be purchased for a few hundred dollars and can run well on desk top PCs with even 386 CPUs. Digital images are made of discrete picture elements (pixels) with which are associated numbers representing the brightness at a particular location in the image. The more points sampled in X and Y, the higher the spatial resolution, typically (but not always) limited to 256 X 256 (65,536 pixels) or 512 X 512 (262,144 pixels) so as not to be too demanding on memory. Brightness too is digitized, being represented by a binary number. Numbers consisting of 2 bits can represent 4 gray levels (00,01,10,11), numbers of six bits, 64 gray levels and so on, the more bits the better the gray level resolution. Digital processing consists of arithmetic manipulation of these parameters and is an incredibly powerful tool to modify the digital image.

Manipulation of contrast, the most commonly used adjustment to the quality of images, which used to be achieved by using different films, different grades of printing papers or filters (see "handwaving, above") can easily be implemented by digital processing. To adjust the contrast of digital images a histogram is constructed showing the number of pixels for each brightness level. A low contrast image would have a low dynamic range, with all the brightness values crowded close to each other. By first sliding all the values downward (by subtracting from each number a value corresponding to the lowest brightness level found in the image), and then stretching the histogram by multiplying all values by a constant number, one can obtain an image where the brightnesses cover the whole dynamic range, say, 0-225 if brightness is encoded as an 8 bit number. Voila!, contrast has been adjusted. No, you don't like what the picture looks like? Well, lets change the way we stretch the histogram, perhaps by multiplying with a logarithmic expression. It is easy to see that, using simple arithmetic operations, images can be adjusted for the "best", the most revealing, result. Advertisements for a recently released program boast that one can even play photographer, "dodging" and "burning" digitally, I.e. apply the same manipulations to only part of the image. So dark room red lights are replaced by the computer screen's blues and grays and the wet and stained fingers of the old pros are replaced by unwettable binary digits.

But playing with contrast and brightness is only the beginning of what can be achieved. Much fancier things can be done easily using techniques which often have great sounding and mysterious names: Phong shading, morphological opening, statistical differencing. Edges can be enhanced, or instead the whole image can be softened. Lighting from any direction can be added where there was none, specular reflections placed. Images can be added to each other, distorted to compensate for defects in the recording system or just for the fun of it. They can be rotated, cropped, magnified or reduced. Colors can be added to code for brightness or other variables. Natural colors can be adjusted. Remember the first color picture of Mars returned by Viking? The surface of the planet was red and above it there was a beautiful clear blue sky like earth, beautiful! Only later did calibration show that the color had been wrong, the sky was really pink, even during the day. Processing to the rescue!

So where does this lead us? Of course it is to ask whether this is cricket, all this manipulation of the data. Does the result show something real? What is real? I don't wish to enter into a philosophical discussion, but the perception of reality does depend on the beholder. A bee sees the world differently from us and so does a dog whose world is monochrome and made as much of smells as of sights. The word of the very small is not visible to us directly, so in a narrow sense of "reality", the very small does not exist, at least not to the unaided eye. In order to circumvent this problem we take the data obtained with our various microscopes and let our imagination roam within the bounds of the observations they make for us. No matter that we use digits instead of fingers, they represent equivalent tools needed to allow us to see the invisible. In digital as in every other kind of microscopy the same rules apply. We make sure that what we observe is real by making multiple observations, preferably under different conditions. We must record not only how the original data was collected but also what manipulation of the data was carried out in order to achieve the image we present. The manipulations must be limited by common sense to doing what is needed to get the best image while not creating features where none exist. Whether encoded by digits or drawn by fingers holding a pen, the images collected by our microscopes are our windows to the invisible. ■

References:

Baxes, A.G.: Digital Image Processing. Prentice-Hall, NY 1984.
Dougherty, E.R.: An Introduction to Morphological Image Processing. Vol TT9, SPIE Optical Engineering Press, Bellingham WA 1992.
Hill, F.S.: Computer Graphics. Macmillan Pub. Co. New Yor, NY 1990.
Niblack, W. Digital Image Processing. Prentice-Hall International, Englewood Cliffs, N.J 1986.
Washburn, M.: Mars, At Last! G.P. Putnam's Sons, NY. 1977, page 236.

COMING EVENTS

(***): **Contact Microscopy Today for further information.**

✓ July 19/23 '93: **Freeze Fracture Course.** Colorado State Univ., Ft. Collins, CO. Eileen Diepenbrock: (303)491-5847.

✓ July 19/23 '93: **School on Computer Simulation and Processing of HRTEM Images.** NCEM, Berkeley, CA. Michael A. O'Keefe: (510)486-4610. Email: MAOK@LBL.GOV.

✓ July 19/23 '93: **HREM Image Processing and Simulation Summer School.** (Nat'l Ctr for Electron Microscopy) LLB, Berkeley, CA. Michael A. O'Keefe: (510)486-4610.

✓ July 31/Aug 1 '93: **A Practical Experience In Cryofixation and Freeze-Substitution.** (MSA Pre-Meeting Workshop) Miami Univ, Oxford, OH. A. Allenspach: (513)529-3100.

✓ August 1/6 '93: **51st Annual Microscopy Society of America (MSA/EMSA) Meeting.** Cincinnati, OH. MSA Business Office: Tel.: (800)538-3672; Fax: (508)548-9053.

✓ August 3/5 '93: **FT-IR Microscopy: A Hands On Sample Preparation Workshop.** Wesleyan Univ., Middletown, CT. Wallace Pringle: (203)347-9411, Ext: 2361/2791

✓ August 9/13 '93: **7th International Conference on STM.** (NSTD Topical Conference) Beijing, China (***)

✓ August 16/18 '93: **TEM Specimen Preparation Course/Workshop.** (Arizona State Univ.) Tempe AZ. Dr. Farhad Shaapur: (602)965-0399.

✓ Sept 5/11 '93: **3rd Joint Meeting on Electron Microscopy.** Zurich, Switzerland (***)

✓ Sept 8/10 '93: **Microscopy/Photomicrography.** American Type Culture Collection. Rockville, MD. Brian K. Wiggins: (301)231-5555.

✓ Sept 26 - Oct 2 '93: **Second International Congress on Electron Microscopy.** Cancun, Mexico. Mario Meki: Tel.: (525)622-50-33, Fax: (525)548-31-11.

✓ Oct 5/7 '93: **Third Annual Analytical Laboratory Exposition and Conference (ALEX '93).** San Francisco, CA. (61&)449-8938.

✓ Oct 25/29 '93: **Scanning Electron Microscopy Field Emission and X-Ray Microanalysis.** (SUNY) Ellenville, NY. Dr. Angelos Patsis: (914)257-3800.

✓ Nov 17/21 '93: **Nat'l Assoc of Biology Teachers Convention.** Boston. (703)471-1134

✓ Nov 15/19 '93: **40th Annual Symposium of American Vacuum Society.** Orlando, FL. Marion Churchill: (212)661-9404.

✓ Nov 29/Dec 3 '93: **MRS Fall Meeting** Boston, MA: (412)367-3003.

✓ Feb 27/March 4 '94: **PITTCON '94.** Chicago IL Alma Johnson (412)825-3220.

✓ May 7/12 '94: **Food Structure Annual Meeting.** Toronto, Canada. Dr. Om Johari: (708)529-6677.

✓ June 26/30 '94: **10th Annual Molecular Microspectroscopy Short Course.** (Miami University) Oxford, OH. (513)529-2873.

✓ July 17/22 '94: **13th International Congress on Electron Microscopy.** Paris, France. Secretariat ICEM 13, 67 rue Maurice Gunsbourg, 94205 Ivry sur Seine cedex, France.