Standard Formats for the Exchange and Storage of Image Data

In microscopy, there is an increasing need for images to be recorded electronically and stored digitally on disk or tape. This image data can be shared by mailing these magnetic media or by electronic transmission along telephone lines (e.g. modem transfer) or special networks, such as Bitnet or Internet. In each case, the format in which the image is stored or transmitted must be known to the recipient in order to correctly recover all the information. Because there are many image formats to choose from, it would undoubtedly save misunderstanding and frustration if a group of individuals with similar interests and needs could agree upon a common format. The Microscopy Society of America Standards Committee has surveyed several formats which could be of particular interest to microscopist, with a view to making a recommendation to our community[1].

Our chief concern has been compatibility with existing software, combined with an adequate representation of the data, compactness of data storage (on disk) and reasonable rate of data transfer. In some forms of microscopy, the image intensity covers a wide dynamic range, demanding a large number of bits per pixel or representation by floating-point numbers. Although data transfer rates can be increased though various forms of data compression, compactness of storage demands that the image by represented in binary code rather than in more immediately readable ASCII numbers. The formats which we have considered include raw binary files, PICT, GIF, FITS, TIFF and HDF. A raw binary file is highly compact but not self-describing: The dimensions of the data array have to be specified external to the dataset. Such a format is too rigid for general use.

PICT is the main graphics format used my Macintosh computers and is recognized by many software programs. In its most recent manifestation (PICT2), grey-scale and color images are supported. Data can be represented by 8-, 16- or 32-bit integers and the file contains other information describing the image. But because this format is not commonly supported by computers which use the DOS and Unix operating systems, we do not recommend PICT as a general standard.

GIF (Graphics Interchange Format) was originally developed for the interchange of files over the CompuServe network. A compression scheme can be used to compact the data and thereby shorten the transmission time. Support for color tables is included, but not floating-point numbers, so we feel that this format is not flexible enough for general microscopy.

FITS (Flexible Image Transport System) is a standard format used by optical and radio astronomers. It is capable of handling large, multidimensional arrays and can support several data types, including ASCII characters, 8-, 16-, and 24-bit integers and floating-point numbers. Each file contains a header (written in ASCII text) to describe the data, which is usually in binary form.

TIFF (Tagged Image File Format) was developed jointly by the Microsoft and Aldus companies in order to store images from scanners and other desktop-publishing equipment in a machine-independent form. It has become the mostly widely used format for the Macintosh and IBM-type personal computers. The data itself can be stored as 8-, 16-, or 32-bit unsigned integers, and (in version 6.0) as signed integers and floating-point numbers. Besides the picture data, a TIPP file may contain supplementary information concerning the ownership, acquisition conditions, etc., and even extensive documentation about the image. Each particular element of information is identified by a tag - a label which the computer needs to interpret the information.

HDF (Hierarchical Data Format) was developed by the National Centre for Supercomputing Applications (NCSA) at the University of Illinois (Urbana). It uses

a machine-independent binary-file standard for recording matrix arrays and other types of scientific data, which can be quite extensive. This format permits flexibility; for example, subarrays corresponding to part of an image can be accessed for read/write purposes. Data are stored as 1- or 3-byte integers, or as floating-point numbers, in binary-format continuous-byte file (not subdivided into blocks).

We see both TIFF and HDF as suitable formats for microscopy. In terms of immediate use, TIFF has the largest amount of support; it is used by all IBM-PC and Macintosh page-scanner programs, by page-layout applications such as Ventura Publisher, QuarkXPress and Aldus PageMaker, and by image-editing applications such as Image, Digital Darkroom, Photoshop, ImageStudio, ImageEdit and Snapshot. Because these applications typically read several formats, they can be used to translate TIFF files into other forms. TIFF is flexible and evolving; it currently allows multiple images per file, several types of data compression, and various types of color image. Because the image data is organized into 'strips', an application program can call into memory only those parts of an image which require processing. TIFF documentarian is available over the Internet network form several FTP sources, including zippy.nimh.nih.gov (see the /pub directory).

Microscopists should remain aware of the HDF standard, which might grow in popularity within the scientific community. NCSA's program Import2HDF can read several 'foreign' formats including TIFF, FITS, PICT, GIF and ASCII Text Files. HDF documentation, source code and Macintosh applications are available free of charge (via anonymous FTP) over Internet (ftp.ncsa.uiuc.edu). ■

1. MSA Standards Committee Report, MSA Bulletin, vol 23, No.2, 1993

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Projector Slide Plates

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The preparation of electron micrographs for 2" x 2" slide presentations is usually done by photographing EM prints with a 35 mm camera. However, for some of our better electron micrographs, many of us have enjoyed printing the negatives directly on 2" x 2" Kodak Projector Slide Plates (#s 140 6875 & 140 6867), which can yield projected images of particularly pleasing tonal quality.

A previous issue of *Microscopy Today* (issue 94-2, March 1994) contained a brief article my me describing a method for making 2" x 2" EM slides with Projector Slide Plates. Unfortunately, it now appears that Kodak has raised the price of these plates to a level that is well beyond what most of us can afford. My first inkling of this came after the article was in the hands of the editor. I telephoned Kodak and confirmed that the price was now about $560 per box of 36 plates, roughly 10 times the former price. However, it still seemed possible that this had been an oversight on the part of Kodak, and that it could be rectified. After another telephone call and a letter, I was finally able to speak on the phone with a Kodak executive, who explained the situation. He said they have had great difficulty getting the emulsion gel components for their various glass plate products and that there was a great deal of waste in manufacturing. As a result, the production of their glass plate products had been operating at a loss for a considerable time. In this era of extremely tight budgets, the Kodak marketing people decided that they had to set realistic prices for their glass plate products that reflected the real cost of making them, plus a reasonable profit. By the time all of this had been clarified, my article was already in press in *Microscopy Today*.

We regret that this fine product is now out of the reach of most electron microscopists. It looks like we will all be using 35 mm copies for our future EM projection slides. Maybe we can print EM negatives on sheet film. Or perhaps the new wave of digitized EM images on computers will allow eventually to make 2" x 2" slides that have whatever tonal quality we desire.