

MELVIN E. CONWAY

NEW APPROACHES TO DIGITAL IMAGE MANAGEMENT

Melvin E. Conway, Ph.D.

A paper prepared for delivery at the Harvard Medical School/
Massachusetts General Hospital Postgraduate Course In Neuro-
radiology, Boston, Massachusetts, October 7, 1976

1. Image Management Defined	1
2. Different Methods Required for Digital Images	1
3. Four Principles of Radiographic Image Management	2
4. Two Novel Patient-oriented Storage Media	3
5. Two Novel Image Management Systems	3

1. Image Management Defined

Radiographic image management is defined here as the set of activities occasioned by the responsibility for the preservation and timely availability of images after they are generated. It encompasses the activities of filing, storage, retrieval, and display. We shall confine our attention in this paper to the management of CT images in digital form. There is the presumption here, made without comment, that it's worthwhile storing CT images in their original digital form, as opposed to storing just photographs of images.

2. Different Methods Required for Digital Images

There are fundamental differences between the representation of data in digital form and in analog form. Values such as opacity to X-rays are represented by numbers in a digital image and by measurement (of film density) in an analog (film) image. Counting and measuring are distinct modes of representation and manipulation of information.

Photographic film is a natural medium for the representation of analog images, but it has inherent limits in spatial resolution and range and precision of density. Naturally digital media such as computer tape can extend either of these limits arbitrarily far, but there is a price to be paid in cost and bulk of the medium, as well as cost of the reading apparatus.

Existing concepts of film image management are widely accepted; indeed, the running of a film library is largely taken for granted. Perhaps it is assumed that the existing film management methods apply equally well to CT images, but this is not necessarily the case. Certainly, the media have very different properties. In fact, there are no generally accepted concepts for CT image management, and the reels of tape are piling up.

3. Four Principles of Radiographic Image Management

Observance of the following four principles maximizes the convenience and utility of an image library. These principles are in practice almost everywhere for films and almost nowhere for CT images. This fact alone demonstrates the inherent differences of the two modalities.

1. Standardization of storage media and recording methods. The transparency film, possessing a certain range of densities, fitting into a jacket of a certain range of sizes, is nearly universal. Among the common CT scanners there are at least three different and noninterchangeable magnetic tape formats and at least one floppy disc format. This principle does not require that there be only one medium; what is important is that there be ready availability of all images, regardless of their media.
2. Standardization of viewing accessories. There is general standardization among viewboxes with respect to their size, amount of illumination, and method of securing the film. Even more importantly, there is virtually zero coupling in these properties between viewboxes and X-ray cameras. You are not constrained in your selection of light box type by which room the procedure was executed in or what the manufacturer of the machine in that room was. With CT the opposite is the case. Today, CT viewers are considered to be captive accessories to scanners. This may be appropriate to today's situation in which the scanner is such a rare bird, but will it always be so? Later I shall suggest that this need not be the case even today.
3. Patient-oriented storage and retrieval of images. Films are filed and retrieved by patient identification. Magnetic tape, today's dominant CT storage medium, cannot be so organized because it is not economical to dedicate even a small reel of tape to each patient. Consequently, magnetic tape libraries are organized chronologically and a patient's complete record may be scattered all about a tape library. The floppy disc is flat so that it can be filed as films are; its problem is that (as it is used now) it often doesn't have the storage capacity to hold a complete study on one disc, and at \$4.00 per unit, using two discs may be uneconomical.
4. Compatibility with associated information. Even within the strict confines of the radiology service, the film does not travel unaccompanied. There is clinical and administrative information whose path parallels the course of the film. Ultimately, some of this information may be stored with the film. When tape is used for CT storage, two filing systems must be created and cross-referenced: the tape file and the paper/film file.

4. Two Novel Patient-oriented Storage Media

Of the following three patient-oriented media, only the first is practical today; one of the others may show promise at some time in the future.

1. Floppy disc
2. Digital microfiche
3. Video disc

I am aware of at least one development of a digital recording method using microfiche and a low-cost reading instrument for recovering the digital data. In one method the recording density is so high that a large series of body scans could easily fit on one fiche. This method has not yet been demonstrated to be practical, but it certainly bears watching.

As for the video disc, if the trade press is to be believed, we are about to witness the start of a marketing duel reminiscent of the 33/45 RPM record battle. RCA is developing a video disc which is largely consumer-oriented, whereas the Philips/MCA optical video disc, while primarily intended for the consumer market, has the potential for such features as stop-action which make it promising in broader markets, such as education and radiology. If this technique survives and if low-cost methods can be developed for creating individual discs in the field, perhaps some new fallout from the consumer marketplace will come to the aid of radiologists.

5. Two Novel Image Management Systems

Neither of the two systems portrayed in the attached figures has, to my knowledge, been realized. Yet each holds out promise in a particular situation, and I am convinced that each is feasible and, in certain circumstances, even justifiable. The first system meets a need for multiple closed-circuit TV viewers, perhaps widely scattered about a hospital complex. In order to eliminate the need to carry physically the digital media to the physicians requesting CT images, all the remote TV monitors are wired to a centralized viewing system which retrieves its images from computer storage. Since the cost of on-line data storage is high, only cases of current interest are stored on line; the archival storage medium is magnetic tape.

Every TV monitor connected to the system is accompanied by a small set of controls, from which the user can request specific images and adjust the window parameters of the image in view. Any requested image which is in the computer file can be called up in a few seconds. Some side benefits of this approach: typed dictation can be recorded on tape with the images, and physical security is excellent since no tapes leave the library. It is even possible for scanners to transmit their images automatically to the computer system as soon as reconstruction is complete, so that all viewing is done through this system, even if the patient is still on the table. This capability can reduce the frequency of repeat scans, if the physician is in a position to judge whether a series being taken is complete does not need to hover about the scanner suite, but can be consulted wherever he or she is.

The second system is a response to the increasing government pressure to limit the number of scanners in certain geographical areas. Even though such pressure may have some success and scanners may be sparsely scattered about, creating isolated focal points of CT scanning, it does not necessarily follow that the physicians with a need to see CT images will be distributed in the same way that the scanners are. Therefore, to the extent that scanners are sparsely distributed, intra- and inter-city traffic in CT images will increase. The promising piece of news is that CT images, being wholly digital, can be transmitted by telephone without any image degradation.

Here is how the system is used. Near each scanner is the tape library which is the product of this scanner. In the outlying region, at any distance reachable by telephone, is an arbitrary number of free-standing electronic viewers, which I have dubbed "TeleCAT". A telephone call from a secretary or technician at any viewer to the tape library makes a request for a study. The librarian retrieves the tape and mounts it on a data transmission instrument connected to the same telephone. The telephone is switched from talk to data mode and the appropriate series of images is transmitted to the viewer at a rate of 2 to 7 minutes per image and recorded on a floppy disc at the viewer. When all requested images have been transmitted, the telephone call is terminated and the outlying floppy disc is ready for the analysis of its images. Upon completion of analysis, the floppy disc may either be preserved in the patient's folder or overwritten with other images.

Each viewer must have the ability to display images from any existing scanner, and each viewer must be able to transmit as well as receive images. In fact, the transmission instrument at the tape library is just another viewer, with a magnetic tape reader attached. The ability of each viewer both to receive and transmit images from any scanner and for viewers to communicate directly with each other offers interesting possibilities for consultation by local or long-distance telephone. Given the addition of a television camera to such a system, it is even possible to visualize the application of these techniques to conventional film images.

Melvin E. Conway, Ph.D. offers consulting, design, manufacturing, and installation services pertaining to CT image management systems.

TV Display Monitors Located Anywhere in Hospital Complex

