Technical Note

New Methods for Image Data Compression and Reduction in Image Archive Requirements

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Since the introduction of digital acquisition of radiographic images [1], digital storage and transmission of images have also become possible. The increasing number of radiographic studies and the increasing number of images for each study have brought attention to data compression as a method for reducing both communication time and the need for archival space. Several methods have been described for electronic data compression [2–5] and for clinical data compression [6, 7]. Because such methods affect communication time and the need for archival space, their use is mandatory for making the transition to a digital radiology department possible. This paper describes four unreported methods for data compression of radiologic images.

Method I: RF Pulse

Pulsed electromagnetic radiation in the RF band (RF pulse) has been used in MR imaging for many years [8]. However, its use in compressing transmitted electronic data has not been described.

In an ordinary electronic transmission cable carrying digital data, the data are com-

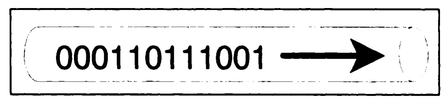
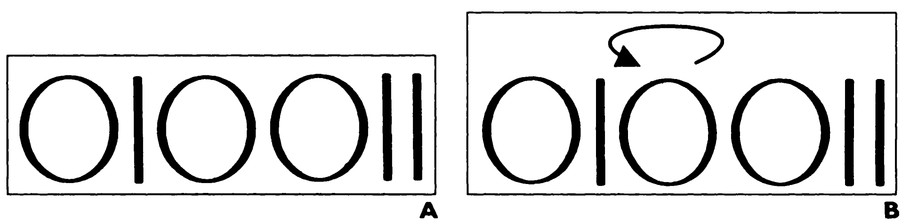
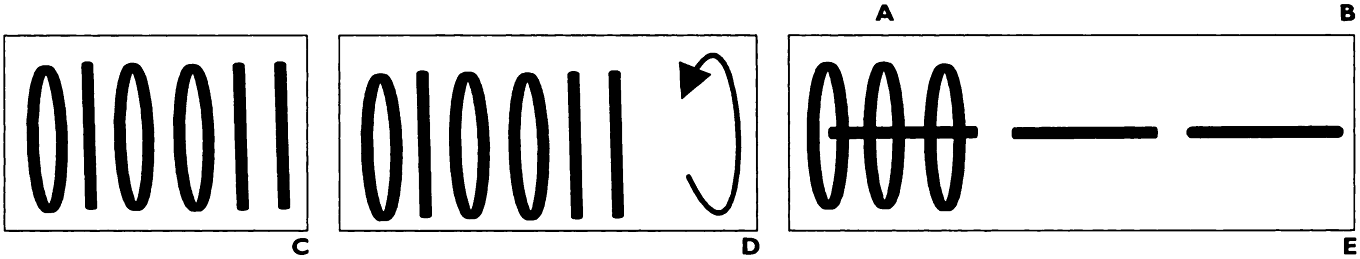


Fig. 1.—Line drawing shows that digital image data is composed of signals of level zero and level one, which are transmitted lengthwise in sequential fashion in transmission cable.

posed of binary signals: ones and zeros (Figs. 1 and 2A). In our new method, such data are modified by using a 90° RF pulse with a resonance frequency suitable for zeros. Thus, the zeros are rotated 90° (Fig. 2B), shortening the

Fig. 2.—Analog representation of digital signals. **A–E**, Normal appearance (**A**) of digital signals (zeros and ones) changes when zeros are rotated 90° (**B**) because of RF pulse, which makes data much more compact (**C**). When ones are also rotated 90° (**D**), note that data become even more compact because ones can now be transmitted through holes in zeros (**E**).





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average data length by a factor as high as five (Fig. 2C). In step two of this new method, another 90° RF pulse is applied with a resonance frequency suitable for ones, which are also rotated 90° (Fig. 2D). With the ones perpendicular to the zeros, their resistance to transmission is significantly reduced. In fact, the ones can be transmitted through the holes in the zeros so that the ones arrive before the zeros (Fig. 2E). However, this speed requires greater tensile strength in the transmission cables and supporting structures because the weight of the cables will increase proportionately with the extra data.

Method 2: Flat Image Long-Term Storage Module

Current methods of storing imaging data employ a lengthwise compression scheme, described in method 1. However, few researchers have addressed the physical properties of storing imaging data. We would like to introduce another new method of data compression, flat image long-term storage modules (FILM) (Fig. 3). Each module, or FILM, can store as many as 201,326,592 bits of data in an analog format. The physical properties of each module are unique; they are impervious to magnetic fields, radiation, and light and are barely sensitive to heat and humidity. Tests of FILM data have shown little deterioration even after 100 years of storage! FILMs can be obtained in various sizes, depending on storage requirements, and can withstand harsh treatment without deterioration of data.

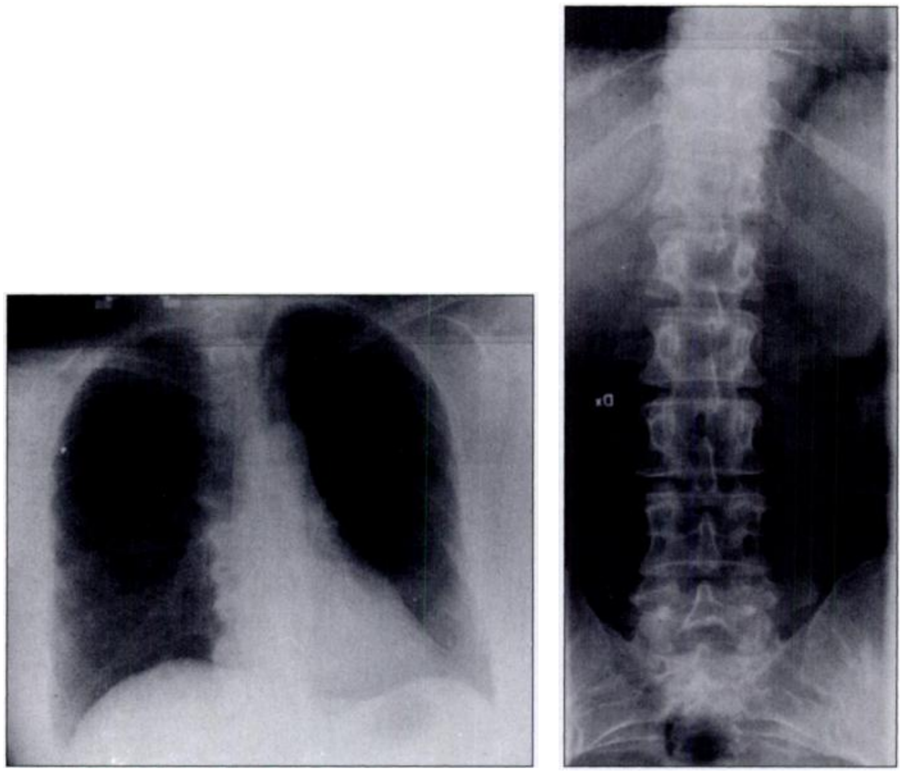
Tests at our institution have shown that several FILMs can be transmitted simultaneously (by parallel transmission) at rates exceeding 500 MB/sec (Fig. 4) over short distances (<10 m). Transmission time, however, does increase with distance.

Image data contained on FILMs can be retrieved by holding each module to a light or to a window, when working during the day. In all other instances, the use of an analog viewing station is recommended (Fig. 5) because the data retrieval rate is more linear and less random than with the conventional monitor-based digital viewing station.

Method 3: Indications

It is a well-known fact that the results of most examinations, even radiologic examinations, are normal. In laboratory services, a gauss distribution of 1–2.5% is regarded as the cutoff for normal values. Such distinct cutoffs are not possible in diagnostic radiology. However, recent studies of chest radiography in an unselected population have shown that as many as 86% of all chest radiographs are normal or show clinically insignificant abnormalities (Geijer et al., unpublished results). This fact leads to the obvious conclusion that radiology reports will be correct in most cases, even if no examinations are made. If, depending on the type of examination, a sprinkling of terms such as "small infarction," "small cortical fragment," "small polyp," and "small calculus" are included in reports, the rate of correct reports and the rate of satisfied customers would increase.

To preserve the psychologic effect of the radiologic examination, patients should be examined on a radiology table. However, no radiation or retakes are necessary. A small electric motor can give the sonic impression of anode rotation. In MR imaging, a larger motor will be necessary, as are large signs alerting the patient to dangerous magnetic fields (which, of course, no longer operate). In this way, both the patient and the referring physician are pleased



A B

Fig. 3.—**A** and **B**, Two examples of examinations stored on flat image long-term storage modules. Note high rate of data compression.

Fig. 4.—Large number of flat image long-term storage modules containing several GB of data show that data can easily be transmitted or stored.

Fig. 5.—Analog viewing station shows optimal retrieval of image data stored on flat image long-term storage modules.

with a speedy examination and no waiting for retakes. The radiation dose delivered to the population shrinks to virtually zero, and the danger of magnetic fields disappears.

For legal reasons, archiving of these pseudoexaminations is necessary. Standardized reports can be compressed to only 1 byte of data when a set of 256 or fewer such reports is used because the patient's file has to contain only the number of the report being used. If 2 bytes per examination are used for the number of the standardized report, a set of 65,536 such reports can be used. Because no images are produced, image storage is no longer a problem. A standardized set of examinations, without examination date or personal data, should be preserved in case a patient or referring physician wishes to review the examination. One shelf should be sufficient to store all examinations.

Method 4: Telefaxradiology

In a pilot study, we evaluated the use of telefaxradiology. Examinations from a peripheral CT unit are printed on an 8 × 10 inch (200 × 250 mm) film and are divided into 25 frames. Thus, an entire CT examination usually fits on a single film. All images are then transmitted by fax to a radiology archive or to the referring physician. The flimsy, incredibly thin fax paper is archived in an ordinary ring binder, which occupies practically no space at all. In the future, this method of data compression can be implemented in large radiology departments. The need for expensive view boxes also becomes unnecessary because ordinary daylight is sufficient to view the images. This change can lead to increased revenue for the radiology department. However, because the fax paper has a limited shelf life, continuous retransmission and reimbursement will be necessary to keep the archive intact. On the other hand, this self-destruction may be a desirable effect with regard to data compression.

Discussion

The four new types of data compression of radiologic images presented in this paper have their uses and limitations. All four methods have been tested in clinical practice, and all methods are fully compatible with the Digital Imaging and Communications in Medicine protocol. Of course, the use of information-preserving and information-losing compression algorithms have been discussed by other authors [4, 9, 10]. With our methods, however, the full data set is preserved and images can be fully restored. The method of data compression used requires consideration of the patient population to be examined and the physicians who write the request for imaging. For example, although the first method has proven useful on image data from the MR imaging unit, we have been unsuccessful in implementing the method in our CT unit. The second method has proven efficient in smaller departments where transmission distances are short. In general, we believe the third method to be the most efficient compression algorithm; however, its use should be limited to preoperative and outpatient examinations until further studies are completed. For various reasons, the third method's use in the emergency department cannot now be recommended. The fourth method of data compression has yet to be evaluated in a general setting.

In conclusion, we believe that the full-scale use of our compression algorithms will lead to speedier acquisition of digital images and their storage in a clinical practice, thereby transmitting diagnostic radiology to another level of expertise and regard.

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