Clinical evaluation of fractal coding technique for dynamic PET data compression

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Introduction: The use of picture archiving and communication system (PACS) has facilitated rapid data retrieval and transmission across computer networks within different hospitals. Medical images, particularly those acquired by positron emission tomography (PET), are more difficult to work with as compared to those obtained from computer tomography and digital mammography, because they are multidimensional (3D space + time) and time-varying. Standard lossless compression schemes have been studied over the past two decades but compression ratios of about 2:1 can be achieved only. Common industrial standards for lossy image compression are designed for non-medical use. Their application to medical image compression is still under investigation. This study evaluates the use of fractal image coding technique to compress clinical neurologic PET data.

Methods: A fractal is a geometric form having self-similar irregular details. We hypotheses that spatial redundancy of a PET image could be eliminated by exploiting the self-similarity present in the image at the microscopic image level. This is different from standard lossy compression techniques that high frequency components of the image are eliminated by storing only low frequency coefficients, or the image is broken up into smaller number of canonical pieces and storing the reference index for each piece together with a codebook. The coding technique applied in this work is based on the quadtree partition algorithm (1). We have applied this algorithm to dynamic neurologic FDG PET data obtained from 10 patients few months after surgical removal of the brain tumor. Emission data were acquired on an ECAT 951R whole-body PET tomograph (CTI/Siemens, Knoxville, TN). Patients were injected with about 400 MBq of FDG and a dynamic sequence of 22 frames was acquired over 60 min. Arterialized-venous blood samples were taken throughout the study. To evaluate the effect of compression on diagnosis, both the mean and the percent standard deviation (SD) of tissue activity concentration in some specific region of interests (ROIs) such as tumors and hot spots were calculated for all time frames. Cerebral metabolic rate of glucose (CMRGlc) was also computed using Patlak analysis (2), for dynamic images reconstructed from coding and was compared with the original images. A paired *t*-test was used for statistical analysis and differences with $P < 0.05$ were considered statistically significant.

Results: It was shown that the compression ratio varied between 5:1 to 20:1, depending on the amount of self-similarity present in the images and the noise levels. The mean value of tissue activity concentration within the ROIs did not change significantly ($P > 0.05$) while the percent SD within the ROIs was decreased but the change was not statistically significant ($P > 0.05$). Regional and pixel-wise comparisons for the calculated CMRGlc were performed and no appreciable difference was observed. The absolute differences between the CMRGlc images computed using the original PET images and the reconstructed images using the fractal image coding technique were less than 5% on average, showing that the diagnostic information is still preserved. These findings were consistent in all studies.

Conclusion: We conclude that fractal image coding technique may be useful in PET image compression. Further investigation on applying this technique to PET data acquired on patients with various neuropathological conditions and to other imaging modalities is warranted.

References:

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