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Evaluation of a Fast Algebraic Reconstruction from Subsets of PET Data

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INTRODUCTION

Positron emission tomography (PET) measurement system has the shift-variant characteristics, caused by the broadened sensitivity functions of each detector at the off center position. Filtered backprojection (FBP), i.e., conventional reconstruction method, does not take into account these characteristics because FBP method assumes projections are obtained by line integral, and this assumption causes a reduction of image quality. On the other hand, the algebraic reconstruction methods such as the generalized analytic reconstruction from discrete samples (GARDS) [1], the natural pixel decomposition (NPD) [2] and the algebraic reconstruction technique (ART) [3] are successfully used for correcting these characteristics, but a large amount of computation is required.

In our resent research, a fast image reconstruction method using an algebraic technique is proposed. This method obtains PET image directly from subsets of projection data using an operator given approximately. In this work, we apply the proposed method to simulated data for a clinical scanner, ECAT EXACT HR+ (Siemens/CTI), and compare the performance of proposed method and of FBP or GARDS.

METHOD

A set of measurement data is represented as $\mathbf{g}=\{g_1, g_2, \cdots, g_N\}$, where N is the number of measurement data. The ith element of sampled original image is given by

$$f_i = \int_C s_i(\mathbf{r})f(\mathbf{r})d\mathbf{r} \qquad (i=1,\cdots,M), \tag{1}$$

where $s_i(\mathbf{r})$ is the sampling function of i-th element (e.g., rectangle function) and M is the number of samples. The proposed method estimate f_i using subsets of measurement data, while conventional algebraic reconstruction methods do using all of data. Now we choose N' ($\leq N$) of measurement data in the order of decreasing contribution to the i-th element and define S_i as a subset of indexes of selected data. Then the estimate of f_i, $\hat{f}_i$, is represented approximately as

$$\hat{f}_i = \sum_{k\in S_i} a_{ik} g_k \qquad (i=1,\cdots,M). \tag{2}$$

The operator $\{a_{ik}\}$ is determined minimizing the ensemble average of $(f_i - \hat{f}_i)^2$ under the condition that preserve the events of i-th element [4]. Once the operator is calculated, it can be employed for all measurement data. Thus the amount of computation to obtain PET images is reduced extremely.

PERFORMANCE OF THE METHOD

In order to evaluate the performance of proposed method for a clinical scanner, the proposed method was applied to simulated data for ECAT EXACT HR+ working in the 2D mode. The field of view is restricted to 26cm in diameter and the 2X angular compression is applied. Then the sinogram becomes116 bins X 144 views a slice. The sensitivity functions are designed considering geometrical arrangement of detectors and penetration of crystals. Scattered and attenuated photons are neglected here.

The figures of merit (FOMs) to evaluate the image quality are spatial resolution, noise, contrast recovery (CR), normalized route mean square error (NRMSE). The spatial resolution is measured as the average of full width at half maximum (FWHM) of the point spread function using the phantom containing 4 point sources. Noise is measured as the root variance of a uniform phantom (2M total counts). Contrast recovery and NRMSE of reconstructed image are found using the warm phantom containing 3 hot cylinders.

The trade off between background root variance and resolution is shown in Fig. 1, using GARDS and the proposed method with different values of regularization parameters, and FBP with a ramp filter with different cut-off frequencies. The other relative FOMs under the condition (background root variance=0.12) for N' are shown in Fig. 2. The FOMs with maximum N' are corresponding to the GARDS. These results show that the proposed method with N' more than 6,000 produces almost same image quality as GARDS. Then we use N'=5,760 as a standard for this simulation. Fig. 3 shows the comparison of resolution at the center slice, and the resolution is improved by algebraic methods. The comparison of calculation time in Table shows that the proposed method has a similar computation time to the FBP.

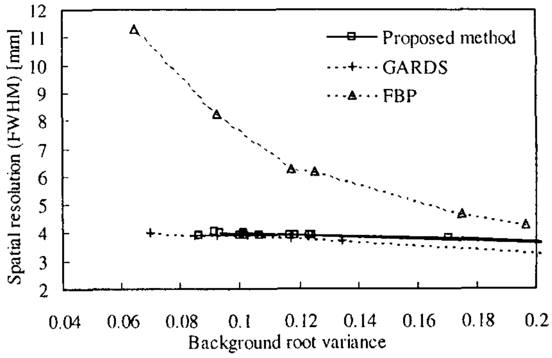

Fig. 1 The trade off between background root variance and resolution.

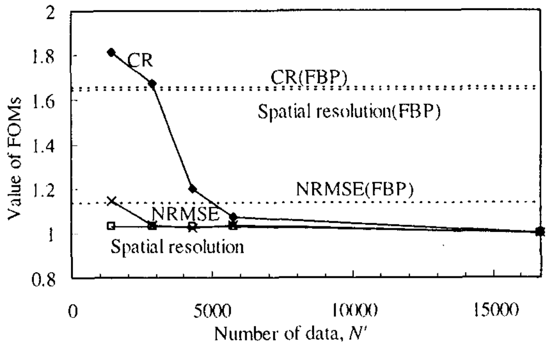

Fig. 2 Relative FOMs under the condition (background root variance=0.12) vs. N'.

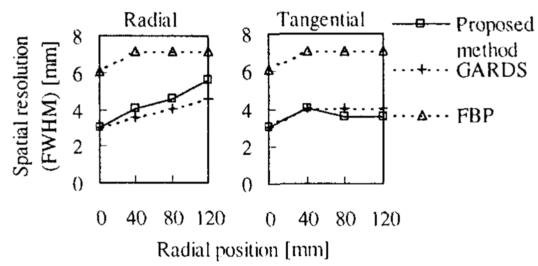

Fig. 3 Spatial resolution at the difference radial position under the condition (background root variance=0.12)

Table: Calculation time on Alpha 500MHz PC.

	proposed mehod	GARDS	FBP
time	**12 s**	3900 s	8 s

CONCLUSION AND FUTURE WORK

A fast image reconstruction method for PET using an algebraic technique was evaluated using simulated data for a clinical scanner. Simulation results show that the proposed method produces images with almost the same quality as algebraic methods do, and has a similar computation time to FBP. Our future work will include evaluation of the clinical performance using experimental data.

REFERENCES

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