Real-Time PET Tomographic Image Reconstruction Based on the Pseudo-Inverse of System Matrices

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INTRODUCTION

• Real-time Positron Emission Tomography (PET) has been proposed in recent years [1], but it requires very fast data processing and reconstruction methods.
• The process can be speeded-up by rebinning the acquired data in the axial dimension into a stack of 2D datasets before the image reconstruction.
• 2D datasets can be reconstructed with standard analytical methods.

METHODS

SYSTEM RESPONSE MATRIX

• PET data (y) and reconstructed images (x) are related by the SRM: y = Ax.
• The SRM contains the probability that a emission from a voxel of the image creates a coincidence in a pair of crystals.
• In this work, we used a model of the preclinical PET-CT scanner SUPERARGUS [9] and the clinical PET-CT scanner Biograph mCT10.

PSEUDOINVERSE

• If the reconstruction problem is considered a linear least squares method (LLSM), the solution can be obtained with the PseudoInverse A⁺ of the SRM [7] X=A⁺Y:

\[ A⁺ = U⁺ S⁺ V⁺ \]

where U, S, and V are the matrices obtained from the SVD decomposition of the matrix A.

RECONSTRUCTION WITH THE PINV

\[ 2D A⁺(x,y,p,θ) \times \text{Sinogram}(p,θ,z,z₂) \times \text{Axial} A⁺(z₁,z₂ : z) = \text{Reconstructed Image}(x,y,z) \]

RESULTS

SSRB+FBP
PINV+FBP
PINV+2DPINV

<table>
<thead>
<tr>
<th>Rebinning Method</th>
<th>Time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSRB</td>
<td>&lt; 0.02</td>
</tr>
<tr>
<td>FORE</td>
<td>15.0</td>
</tr>
<tr>
<td>PINV</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Table 1. Approximated computing times for different rebinning methods studied in this work. These times were computed using FORTRAN in a CPU E5-2654 v4 @ 2.40 GHz processor.

Fig 1. Transverse (up) and Sagittal (down) view different reconstructed images of a real acquisition of a rat with FOV using SUPERARGUS scanner. Comparative between SSRB+FBP (left) with PINV+FBP (middle) and PINV+2DPINV (right).

<table>
<thead>
<tr>
<th>Reconstruction Method</th>
<th>Time (s)</th>
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</thead>
<tbody>
<tr>
<td>FBP</td>
<td>4</td>
</tr>
<tr>
<td>PINV</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 2. Approximated computing times for the different 2D reconstruction methods studied in this work. These times were computed using FORTRAN in a CPU E5-2654 v4 @ 2.40 GHz processor.

REFERENCES


SUMMARY AND CONCLUSIONS

• PseudoInverse-based rebinning methods outperform SSRB in terms of resolution for non-centered sources.
• PseudoInverse methods provide a accurate data rebinning and can be implemented for real time applications, while other methods such as FORE are not fast enough.
• PseudoInverse 2D image reconstruction is an accurate alternative to FBP and can provide similar results even in less computational time.