

Efficient Optimization Based on Local Shift-Invariance for Adaptive SPECT Systems

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For adaptive SPECT we want an efficient setting optimization method, according to a given figure of merit.

Li and Meng [1] have used the variance of a post-filtered MAP reconstructed voxel of interest (VOI) to optimize the angular sampling strategy of a SPECT system. The variance was computed analytically, using the Fisher information matrix (FIM) [2, 3]. Then its partial derivatives with respect to the angular imaging times were used in an iterative gradient-based algorithm to minimize the figure of merit. To speed up the calculations, the object-space was non-uniformly pixelated, which reduces the total number of image voxels but does not discard the need for two matrix inversions per iteration in the optimization.

Building on this, we present an efficient method for real time optimization of the imaging time distribution, while keeping the object-space pixelation uniform. To decrease the computation load, we applied the local shift-invariant approximation [4, 5] to the FIM per angle and unit of time, so that the calculation of the figure of merit and its partial derivatives becomes trivial, and no matrix inversions are needed. This was the most computationally intensive step, and still we only used 3-D fast Fourier transforms; most importantly, it only needs to be done once, and not for every iteration. We also altered the optimization algorithm to achieve faster convergence, and then applied it to maximize the contrast-to-noise ratio (CNR) of a post-filtered MLEM reconstructed VOI (Figure 1). The results were validated for a single-head single-pinhole system; this was done by comparing the analytically computed CNRs, both for the uniform and optimal time distributions, with the values obtained through reconstructions [6]. We observed a similar behavior of the CNR when changing the time distribution (Table 1).

In the future we plan to adapt this procedure to the small animal SPECT systems installed in our lab (X-SPECT and U-SPECT-II).

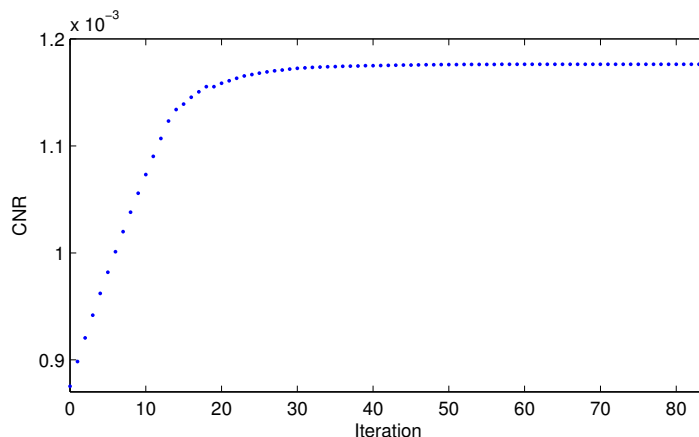


Figure 1: Plot of the analytical CNR versus iteration during the optimization.

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| | UT | NUT | Relative Increase |
|----------------|-------------------------------|-------------------------------|-------------------|
| Approximation | $CNR = 8.7527 \times 10^{-4}$ | $CNR = 11.764 \times 10^{-4}$ | 34% |
| Reconstruction | $CNR = 6.7478 \times 10^{-4}$ | $CNR = 9.3234 \times 10^{-4}$ | 38% |

Table 1: Comparison between the predicted and the observed CNRs, for the uniform time (UT) and optimal non-uniform time (NUT) distributions.

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