Simultaneous MR-PET Reconstruction with Multi-Sensor Compressed Sensing

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Introduction: State-of-the-art MR-PET scanners allow simultaneous data acquisition. However, image reconstruction is performed separately and results are only combined at the visualization stage. We propose a new iterative joint reconstruction framework based on multi-sensor compressed sensing [1,2] that exploits anatomical correlations between MR and PET.

Methods: Joint image reconstruction is formulated by solving for a solution that minimizes the following cost functional:

$$\min \left\| E(x_{MR}) - k \right\|_2^2 + \sum_{j=1}^{J} \left((A(x_{PET}))_j - f_j \log(A(x_{PET}))_j \right) + \lambda_i \left\| \begin{matrix} \Psi(x^i{}_{MR}) \\ \Psi(x^i{}_{PET}) \end{matrix} \right\|_{2,1}$$

x_{MR} and x_{PET} are 3D image volumes with k and f being the measured rawdata. E and A are MR and PET forward operators. Ψ is a sparsifying transform, i and j are voxel and PET rawdata indices, J is the total number of PET projections and λ_i is a spatially adaptive regularization parameter.

Results and discussion: An example of reconstructions from a 3T MR-PET unit (Siemens Biograph mMR) using a 3D-MPRAGE sequence (TR/TE/TI=2300/2.98/900ms, FA=9°, R=2, 24 ACS lines, 256 matrix, voxel size=1×1×1mm^3, 192 slices) for MR data acquisition are shown in **Figure 1**. Joint MR-PET reconstruction improves resolution in PET images when structures are aligned with MR without degrading SNR.

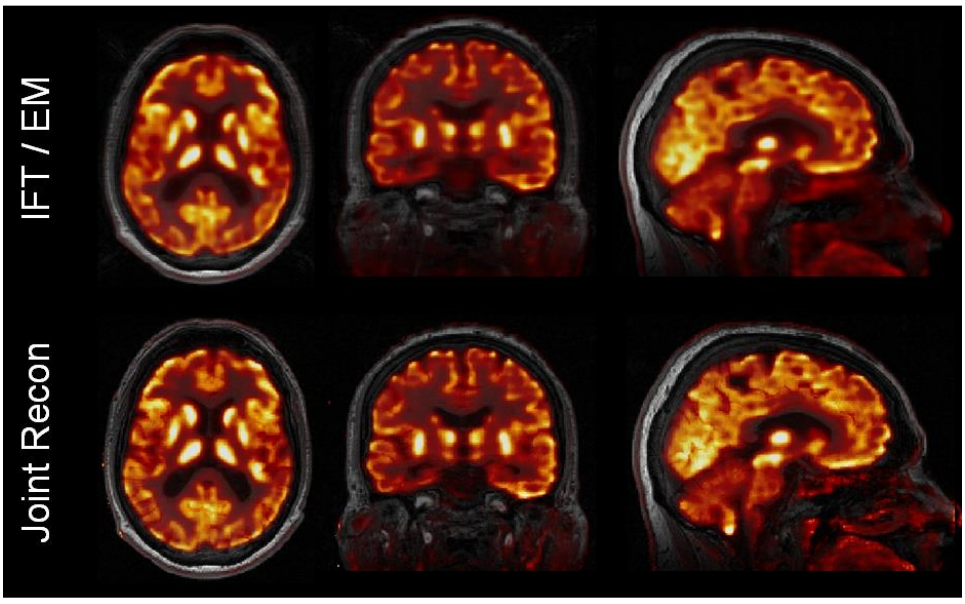

Figure 1: Conventional Inverse Fourier Transform-MR and EM-PET reconstruction (top) and proposed joint reconstruction (bottom). Note the improved spatial resolution of the PET data, in particular superior depiction of the sulcal spaces in the joint reconstruction results.

References: [1] Fornasier and Rauhut, SIAM J Numer. Anal. (2005), [2] Tropp et al. Proc IEEE ICASSP 2005.