

MEETING ABSTRACT

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4-D PET joint image reconstruction/non-rigid motion estimation with limited MRI prior information

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Motion compensated gated PET image reconstruction methods include joint-reconstruction (JR) and indirect reconstruction (IR) with pre-estimated motion from MRI (MRI-IR). JR suffers from poor PET data quality whereas MRI-IR requires high-quality MRI volumes at each gate. We propose a penalised maximum-likelihood approach combining JR and MRI-IR. Our method is referred to as *minimal MRI prior* JR (MP-JR).

The M gates data are stored in $\mathbf{g} = [\mathbf{g}_1; \dots; \mathbf{g}_M]$ where \mathbf{g}_m is the measurement vector at gate m . Each \mathbf{g}_m is a Poisson distributed vector of parameter $\bar{\mathbf{g}}(\mathbf{f}, \alpha_m) = \mathbf{P}W(\alpha_m)\mathbf{f} + \mathbf{r}_m$ where \mathbf{P} is the projector, $W(\alpha_m)$ is the m -th motion of parameter α_m , \mathbf{r}_m is the m -th average random/scatter vector and \mathbf{f} is the activity at $m = 1$. JR is achieved with (1).

$$\text{minimise } L(\mathbf{f}, \alpha) = -\sum_{m=1}^M \sum_{i=1}^I g_{i,m} \log \bar{g}_i(\mathbf{f}, \alpha_m) + \bar{g}_i(\mathbf{f}, \alpha_m) \quad \text{w.r.t. } \mathbf{f}, \alpha \quad (1)$$

MRI-IR is achieved by solving (2)

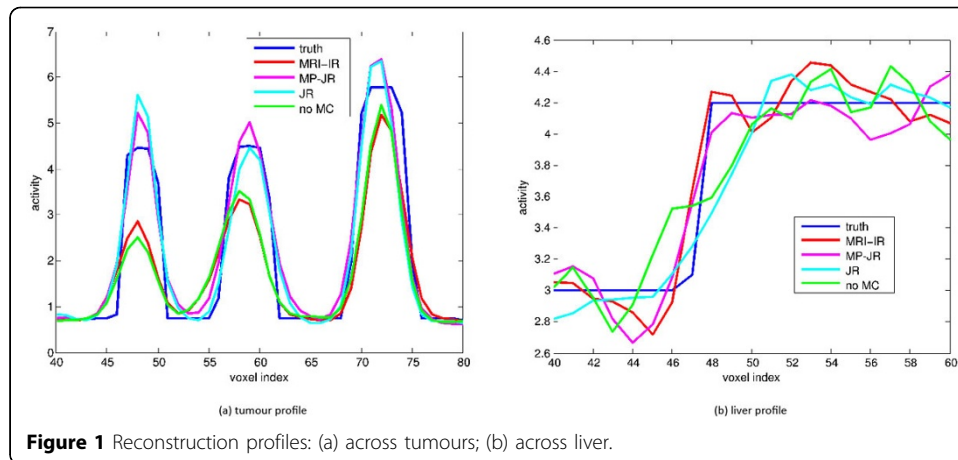
$$\text{minimise } L(\mathbf{f}, \alpha^{mri}) \quad \text{w.r.t. } \mathbf{f} \quad (2)$$

MP-JR is achieved with (3).

$$\text{minimise } L(\mathbf{f}, \alpha) + \beta \sum_{\ell \in S} \|\alpha_\ell - \alpha_\ell^{mri}\|_2^2 + \gamma \sum_{m=1}^{M-1} \|\alpha_{m+1} - \alpha_m\|_2^2 \quad (3)$$

The first term accounts for PET data, whereas the second term accounts for MRI motion information from subset S . The last term controls temporal smoothness.

We tested each method on 9 PET FDG volumes generated from a real dynamic MRI sequence. Tumours were added to the activity distribution (invisible in the MRI). The gates subset S for MP-JR contains the reference gate, end-inspiration and end-expiration. Reconstruction profiles 1 show that MRI-IR improves edges visible in the MRI but degrades the tumours. On the contrary, JR performs well on tumours, but the



edges are poorly reconstructed. MP-JR appears to perform well on both organ edges and tumours.

MP-JR seems to perform well where both JR and MRI-IR under-perform. This is due to the fact that MP-JR relies on both MRI and PET data. In addition, results tend to show that with temporal smoothing on B-spline parameters, a subset of MRI volumes provides sufficient information.

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