Simultaneous Multi-Bed MAP Reconstruction with CT-Guided Directional TV Prior for Y-90 PET SIRT

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Text Yttrium-90 (Y-90) microspheres are used clinically for selective internal radiation therapy (SIRT) for unresectable liver cancers and have been proposed for glioblastoma[1,2]. Accurate dosimetry is critical but remains challenging due to low-count PET data arising from Y-90's low positron branching ratio, as well as accurate treatment of bremsstrahlung for SPECT. Anatomically guided edge-preserving regularisation has shown promise for improving reconstruction quality under such conditions[3]. Whole-organ PET scans often exceed the axial field-of-view, requiring acquisition across multiple, partially overlapping bed positions (BPs). A common approach reconstructs each BP separately and merges them via sensitivity-weighted averaging. However, in overlap regions, low counts and edge-preserving priors can interact to produce intensity discontinuities that obscure image features. We introduce a maximum-a-posteriori (MAP) framework that reconstructs all BPs jointly, with a CT-guided directional total variation (DTV) prior function applied over a combined image volume[4]. We evaluate this method for Y-90 PET following SIRT.

Y-90 SIRT PET data was acquired on a GE Discovery 690 using two BPs, with overlap centred on the liver. We compared two workflows:

1. **Separate + Fuse** – independent reconstructions with sensitivity-weighted merging post-reconstruction.

2. **Joint – Simultaneous** reconstruction of both bed positions using a combined image volume, with separate updates computed for the data-fit terms per bed position and a single joint update for the prior term.

Visual assessment shows that Separate + Fuse obtains abrupt changes in intensity in the overlap region due to noise. The Joint method suppresses these artefacts and yields a smoother, anatomically consistent distribution (Figure 1).

Simultaneous reconstruction of multiple bed positions with a CT-guided DTV prior reduces overlap artefacts and enhances qualitative fidelity in Y-90 SIRT PET.
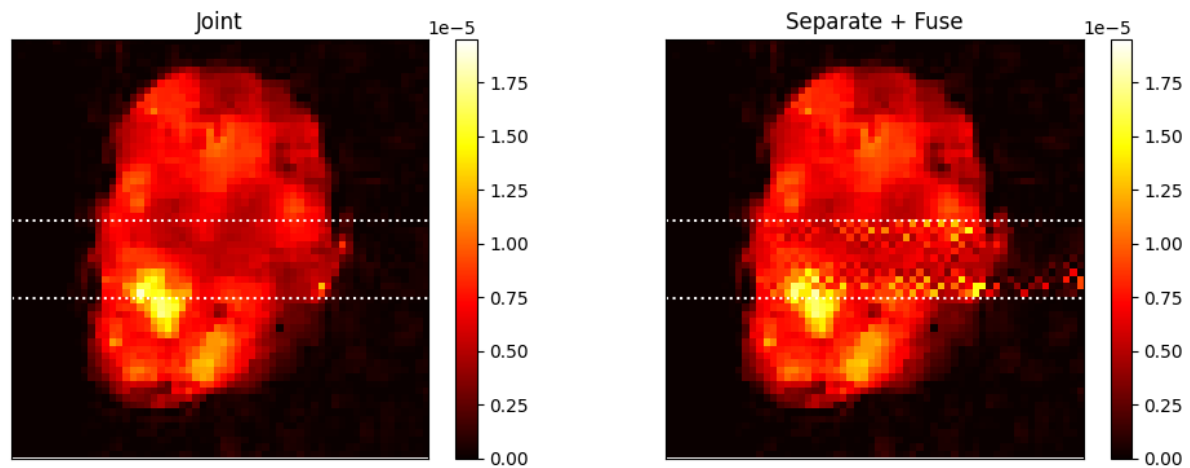
Figure. 1 Comparison of reconstruction methods for Y-90 SIRT PET. Left: Joint reconstruction using a CT-guided DTV prior produces a smooth, anatomically consistent distribution. Right: Separate + Fuse reconstruction introduces intensity discontinuities in the overlap region. White dotted lines indicate the bed overlap area.

References:

(1) NICE, "Selective internal radiation therapy for neuroendocrine tumours" IPG786, 2024

(2) S. Ansari et al., "A first-in-human feasibility study to evaluate the safety of selective intra-arterial yttrium-90 microsphere treatment in patients with recurrent glioblastoma (FRONTIER trial)", J. Neuro Interv. Surg., 2023

(3) D. Deidda et al., "Triple modality image reconstruction of PET data using SPECT, PET, CT information increases lesion uptake in images of patients treated with radioembolization with 90Y micro-spheres", EJNMMI Phys., 2023

(4) Ehrhardt MJ et al., PET Reconstruction With an Anatomical MRI Prior Using Parallel Level Sets", IEEE TMI., 2016