Joint Reconstruction of PET-MRI by Parallel Level Sets

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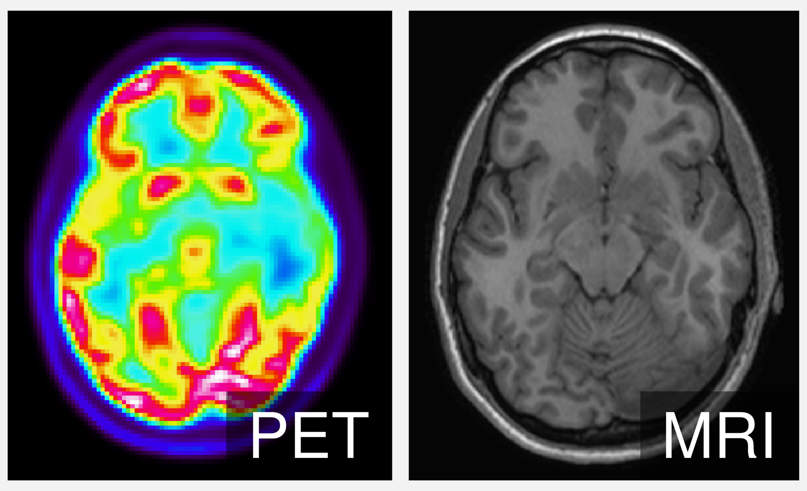
Motivation: Similar Structures

Combined Positron emission tomography (PET) and magnetic resonance imaging (MRI) scanners acquire functional and anatomical data simultaneously [1]. We aim to exploit the expected similarity during reconstruction.



Method: Parallel Level Sets

We perform *joint reconstruction* [2] by minimizing

$$\operatorname*{argmin}_{u,v} \|A(u) - f\|^2 + \|B(v) - g\|^2 + \alpha \mathcal{R}(u, v)$$

where the *parallel level sets* functional [3]

$$\mathcal{R}(u, v) := \int [\![\nabla u]\!] \, [\![\nabla v]\!] - [\![\langle \nabla u, \nabla v \rangle]\!]$$

ensures the regularity and structural similarity of the solution. The smoothed norm $[\![x]\!] := (\|x/\beta\|^2 + 1)^{1/2}$ regulates which gradients should be taken into account.

This approach was successfully applied to colour image processing [3]. Similar functionals have been used in geophysics [4, 5], colour image processing [6], EIT [7] and multi-modality image registration [8].

Analysis of the Diffusion

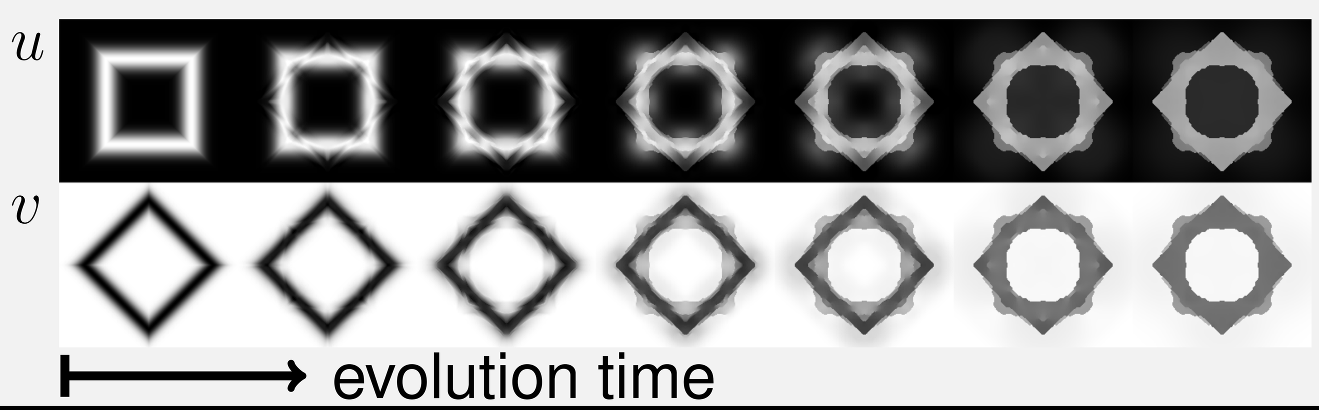
The derivative of $\mathcal{R}$ with respect to (u, v) takes the form

$$D\mathcal{R}_{u,v} = -\operatorname{div} \begin{pmatrix} K(u,v)\nabla u \\ K(v,u)\nabla v \end{pmatrix}$$

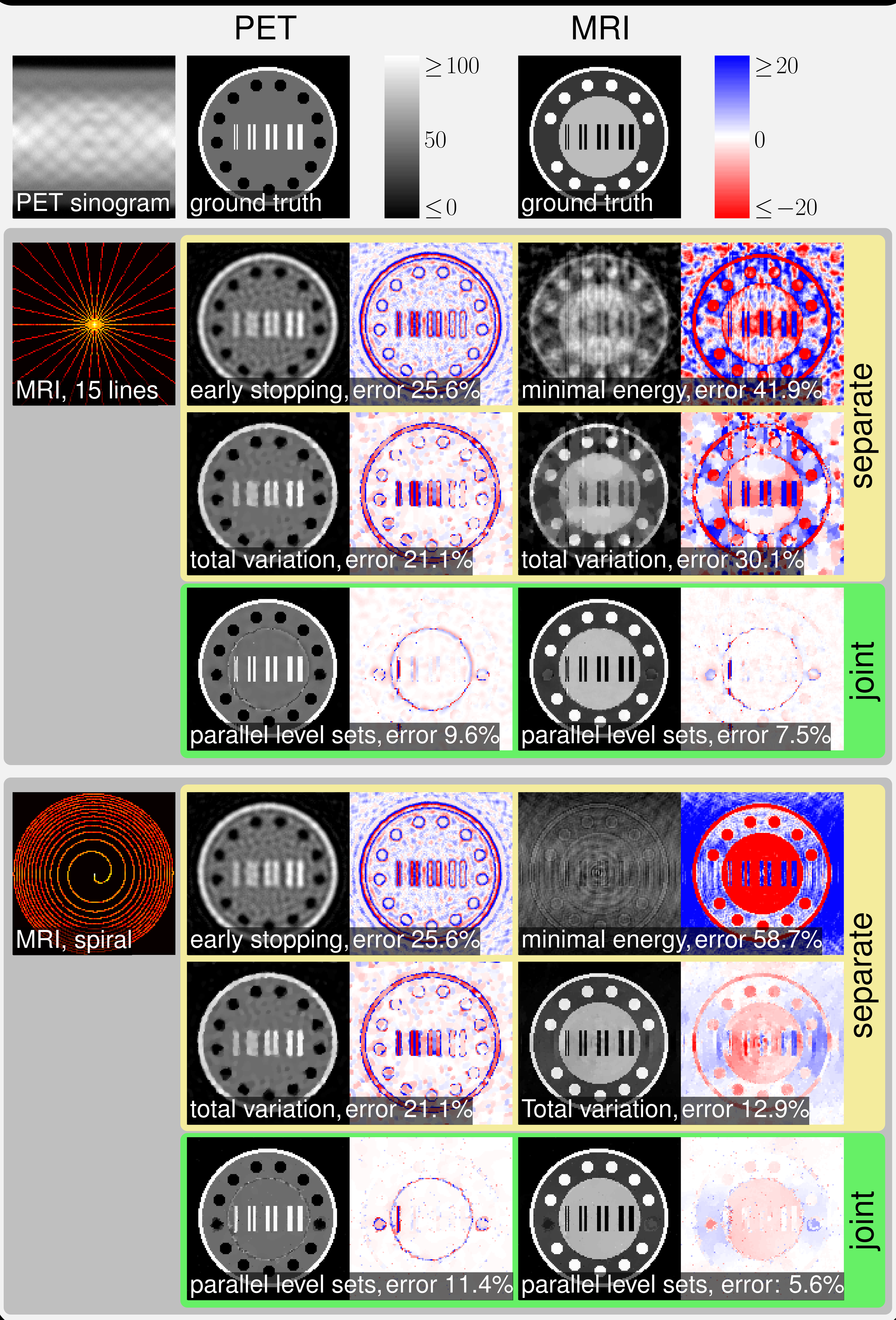
where the diffusivity

$$K(u, v) := [\![\nabla v]\!] \, [\![\nabla u]\!]^{-1} Id - [\![\langle \nabla u, \nabla v \rangle]\!]^{-1} \nabla v \nabla v^T$$

couples the equations. This results in a flow for u where the principle directions are dictated by v and vice versa. If the edges are aligned there is no flow across the edges. The figure shows the evolution of u and v minimizing the parallel level sets functional.



Numerical Results



Conclusions

By coupling two modalities in a joint reconstruction we make use of more information. The images are sharper and of higher quality than separate reconstructions. Errors are greatly decreased in areas of joint edge information.

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