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Omni-tomography/Multi-tomography -- Integrating Multiple Modalities for Simultaneous Imaging

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Current tomographic imaging systems need major improvements, especially when multi-dimensional, multi-scale, multi-temporal and multi-parametric phenomena are under investigation. Both preclinical and clinical imaging now depend on in vivo tomography, often requiring separate evaluations by different imaging modalities to define morphologic details, delineate interval changes due to disease or interventions, and study physiological functions that have interconnected aspects. Over the past decade, fusion of multimodality images has emerged with two different approaches: post-hoc image registration and combined acquisition on PET-CT, PET-MRI and other hybrid scanners. There are intrinsic limitations for both the post-hoc image analysis and dual/triple modality approaches defined by registration errors and physical constraints in the acquisition chain. We envision that tomography will evolve beyond current modality fusion and towards grand fusion, a large scale fusion of all or many imaging modalities, which may be referred to as omni-tomography or multi-tomography. Unlike modality fusion, grand fusion is here proposed for truly simultaneous but often localized reconstruction in terms of all or many relevant imaging mechanisms such as CT, MRI, PET, SPECT, US, optical, and possibly more. In this paper, the technical basis for omni-tomography is introduced and illustrated with a top-level design of a next generation scanner, interior tomographic reconstructions of representative modalities, and anticipated applications of omni-tomography.

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