Hey all,

Here's what's been going on in medical physics and related areas the last 24 hours. Here's what you folks might find interesting today.

Novel Architectures and Objectives for Imaging

SIMPLE-4D: Portable surrogate-free 4D MRI from standard fast multi-slice 2D MRI via implicit neural representations - This paper introduces a software-first, acquisition-agnostic pipeline for **4D MRI reconstruction** that operates entirely on standard reconstructed 2D Cartesian slices, requiring no pulse-sequence modification, navigator, or external hardware. The architecture combines a surrogate-free variational motion encoder with a hash-encoded **implicit neural representation** using a SIREN deformation network, producing bidirectional cycle-consistent DVFs. The **physics-aware** component uses motion-dependent Gauss-Legendre thick-slice quadrature to model the slice acquisition process, and the bidirectional motion model supports downstream **dose accumulation** without retraining, making it directly relevant to **radiotherapy** workflows. Validated on both 1.5T clinical and 0.5T open-bore scanners, with the INR template acting as an implicit denoiser on low-field data (+132% SNR). The systematic ablations isolating each component's contribution are a nice touch.

SAMRI-3D: Adapting SAM2 for 3D MRI Segmentation with Global Volume Tokens - This work adapts SAM2 for MRI-specific 3D segmentation by introducing **Global Volume Tokens** (GVT) - persistent memory tokens trained with a **Truncated Signed Distance Field (TSDF)** reconstruction objective that is discarded at inference, adding zero computational cost. The TSDF objective is a **geometric prior** that helps most where per-slice contrast is weakest, directly targeting the problem of invisible boundaries in MRI. The benchmark is the largest MRI-only evaluation to date (10,392 volumes, 34 datasets), and the full model shows no accuracy drop on 8 held-out datasets (0.79 unseen vs. 0.78 seen), suggesting genuine generalization rather than overfitting to seen anatomical domains. The architectural primitive of training auxiliary geometric objectives that are free at inference is a transferable idea worth noting.

Imaging Physics and Reconstruction

Continuous 3-D Latent Diffusion for Medical Generation and Reconstruction - This paper introduces a **continuous 3D latent diffusion** framework for CT and MRI generation and measurement-guided reconstruction, using a coordinate-conditioned local implicit image function (LIIF) decoder that represents volumes as continuous functions of spatial coordinates. The key architectural innovation is evaluating the convolutional decoder once on the latent grid while restricting repeated computation to a lightweight implicit head, making it 12-32x faster than reference autoencoders on 512^3 CT volumes with the lowest GPU memory footprint. The frozen 3D latent prior supports both unconditional generation and **measurement-conditioned reconstruction** (sparse-view CT, accelerated MRI) through hard data consistency, without task-specific retraining. While direct pixel-domain reconstruction remains more accurate, the demonstration that a single volumetric latent prior can serve both generation and inverse problems on one GPU is a practical contribution.

Theoretical derivation of blood velocity from TOF-MRA based artery centerline - This paper derives a **physics-informed** framework to extract blood velocity directly from standard TOF-MRA signal profiles by analytically expanding the Bloch equations into Bloch-McConnell flow equations, establishing a mathematical relationship between longitudinal magnetization spatial decay and fluid velocity. The **inverse problem** is solved via global optimization with Dual-Tikhonov regularization to stably invert the ill-posed transit time integral, penalizing high-frequency numerical ringing while preserving structural curve stiffness. Validated in simulation on variable-geometry flow cases (continuous tapering, focal stenosis) under synthetic scanner noise, successfully recovering ground-truth point-wise velocities including sharp stenotic jets. This is a proof-of-concept that quantitative hemodynamic metrics can be extracted from structural MRA without additional phase-contrast scans, and the **forward-model-aware** derivation from first principles is the kind of approach that could inspire similar physics-derived inversion in other modalities.

Until the next announcement!

P.S. In the most recent submission window: physics.med-ph: 7 papers cs.CV: 100 papers