Hey there,

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

Radiotherapy and Hadron Therapy / Industry-Relevant and Translational Work

- One-for-All Adaptive Radiotherapy Planning Agent: A Foundation Framework for Daily CBCT-guided Radiotherapy This paper introduces a unified foundation-model-based system that performs complete, treatment-specific online adaptive planning directly from daily cone-beam CT in under two minutes. The agent autonomously predicts essential planning components like synthetic CT generation, multimodal alignment, and tumor/organ segmentation, and then leverages these to execute the final clinical plan design. What is particularly novel here is the "human-in-the-loop" framework that allows clinicians to define planning with intent and intervene at critical decision points before final approval. Evaluated across multiple cancer types and both photon and proton therapy, it achieves clinically acceptable accuracy and plan quality, highlighting the promise of scalable, fully automated online adaptive radiotherapy.

Imaging Physics and Reconstruction / Novel Architectures and Objectives for Imaging

- K-NeAS: Scalable Multi-Material CT Reconstruction Using Neural SDFs This work tackles sparse-view CT reconstruction by proposing a unified architecture for automated, multi-material surface reconstruction using neural signed distance functions (SDFs). The authors replace independent material networks with a shared latent backbone and introduce a fully differentiable K-material sequential soft selector to model an arbitrary number of overlapping tissues. To eliminate manual tuning, they automate attenuation bounding using a Gaussian Mixture Model and implement a scheduled auxiliary floater loss to mitigate geometric hallucinations under extreme sparsity. This is a strong contribution to ML-physics hybrids for image reconstruction, successfully scaling to arbitrary material counts and improving robustness in complex multi-tissue regions like the abdomen.

Uncertainty Quantification and Likelihood-Free Inference / Novel Architectures and Objectives for Imaging

- Beyond scalar losses: calibrating segmentation models via gradient vector field surgery Addressing the notorious miscalibration and overconfidence of models trained with region-based loss functions like Dice, this paper offers a novel gradient perspective on the problem. The authors propose a "surgery" on the gradient vector field that adds a factor to the loss's partial derivative, scaling the gradient's magnitude linearly with the prediction error. This simple yet effective intervention mitigates calibration issues while maintaining high prediction accuracy when used with any region-based loss function. This matters significantly for clinical adoption, where calibrated uncertainty in tasks like defining tumor resection margins is critical.

- DINE: Distance Is Not Enough -- Learning Global Deformation Priors for Robust Soft-Tissue Point Cloud Registration This paper addresses the challenge of non-rigid point cloud registration for soft-tissue shape analysis by moving beyond purely local objectives like Chamfer distance. The authors introduce DINE, a maximum a posteriori framework that augments distance-based registration with a learned statistical prior over displacement vector fields. They compare a full-field PCA Gaussian prior with a per-vector normalizing-flow prior, showing that constraining global deformation plausibility significantly improves robustness to large deformations, noise, and outliers. This approach provides a principled, probabilistic method to enforce physical plausibility in deformation fields, which is highly relevant for reliable soft-tissue tracking and registration.

Back tomorrow with more!

P.S. In the most recent submission window: physics.med-ph: 2 papers cs.CV: 100 papers