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3785

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Topic (read-only)

Physics: Inter-fraction motion management and daily adaptive radiotherapy

Keywords (read-only)

Synthetic-CT, adaptive, thorax

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Abstract title (read-only)

Diffusion-based synthetic-CT generation from thorax CBCT

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Purpose/Objective (read-only)

Cone-beam CT (CBCT) imaging is widely used in radiotherapy for daily patient setup; however, its clinical application remains limited by suboptimal image quality, spatial resolution, and field of view. Extending CBCT beyond positioning could be key to realising the full potential of adaptive radiotherapy. Achieving this requires improved image fidelity to support accurate organ-at-risk delineation, dose calculation, and treatment replanning. This study presents and clinically evaluates an AI–driven approach to generate synthetic-CT (sCT) images from CBCT, addressing major technical limitations and demonstrating feasibility for enhancing adaptive workflows in lung cancer management.

Material/Methods (read-only)

Developing a 3D multimodal translation model for medical imaging presents challenges, including the computational burden of volumetric data, limited availability of high-quality paired datasets, and the need to preserve quantitative accuracy for clinical use. To overcome these, a 3D latent diffusion model was designed. Its variational autoencoder (VAE) component enables strong data compression while maintaining reconstruction fidelity and computational efficiency. The diffusion model was first trained in an unsupervised manner on unpaired data, then fine-tuned for cross-modality translation using limited paired samples. A ControlNet-based conditioning mechanism was implemented to ensure anatomical consistency and quantitative reliability of the generated images. The unsupervised model was trained on approximately 34000 CT scans (50% pelvis, 37.5% head and neck, 12.5% thorax) to ensure anatomical diversity, followed by fine-tuning with 286 thoracic cancer patients (2097 paired datasets).

Results (read-only)

Median relative differences in dose–volume histogram (DVH) parameters for target volumes between sCTs and wCTs were minimal (0.14–0.40% - Table 1), with the largest observed for Dmax (0.40%) and the lowest for D50% (0.14%). Median gamma pass rates reached 99.75% (2%/2 mm) and 99.94% (3%/3 mm) at a 1% low-dose threshold (Table 2), confirming excellent dosimetric agreement.

Structure	DVH parameter	Median relative difference (%)
Target volumes	Dmax [Gy]	0.40
	Dmean [Gy]	0.20
	D2% [Gy]	0.28
	D5% [Gy]	0.22
	D50% [Gy]	0.14
	D95% [Gy]	0.32
	D98% [Gy]	0.39

Gamma index	2%/2mm			3%/3mm		
Low dose threshold	1%	10%	20%	1%	10%	20%
Median	99.81	99.64	99.57	99.97	99.94	99.92

Conclusion (read-only)

This work demonstrates the feasibility and dosimetric accuracy of AI-generated sCTs from CBCT images in lung cancer radiotherapy. The results highlight the potential of this approach to improve image quality, enable accurate dose calculation, and streamline adaptive workflows for personalised and efficient treatment delivery.

Conflict of Interest Disclosure (read-only)

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