

Optimizing biplanar X-ray angles for deep learning-based CT reconstruction for accurate patient positioning in image-guided radiotherapy

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Radiation therapy demands high precision in patient positioning due to its tumor-conformal dose distribution characteristics. Image-guided radiotherapy (IGRT) is employed to verify and ensure accurate patient positioning prior to treatment, thereby reducing uncertainties in the exact location of the planning target volume (PTV). Digital X-ray imaging, a common modality in IGRT, typically utilizes two orthogonal projections to visualize the patient's position from different perspectives (Figure 1). However, while X-rays provide two-dimensional images, the PTV is defined using three-dimensional (3D) images obtained from computed tomography (CT) scans. To align these, image registration is performed by comparing digitally reconstructed radiographs (DRRs) with acquired X-ray images. This DRR-based registration, however, suffers from a limited capture range, reducing robustness in clinical settings. Recent advances in deep learning have shown promising results in reconstructing 3D CT volumes from just two X-ray projections. Biplanar X-rays obtained from different angles provide complementary anatomical information, which is essential for accurate volumetric and stereoscopic reconstruction. Figure 2 illustrates the deep learning architecture used in this study—X2CT-GAN—which employs two parallel encoder-decoder networks to process posterior-anterior (PA) and lateral (LAT) X-rays, with a fusion network integrating features from both views. In this study, we analyze the impact of varying biplanar X-ray angle combinations on the accuracy of 3D CT reconstruction. We evaluate nine different angle pairs ($\theta = 10^\circ\text{--}90^\circ$) to identify the optimal configuration. Preliminary reconstruction results are shown in Figure 3. Quantitative evaluation using the structural similarity index measure (SSIM) and peak signal-to-noise ratio (PSNR) shows that the best performance is achieved at $\theta = 70^\circ$, with SSIM of approximately 0.59 and PSNR of 26.7 dB. Additionally, organ segmentation is performed to qualitatively assess the anatomical accuracy and boundary clarity of the reconstructed CT volumes. Comprehensive experimental results and analysis will be presented in the full paper.

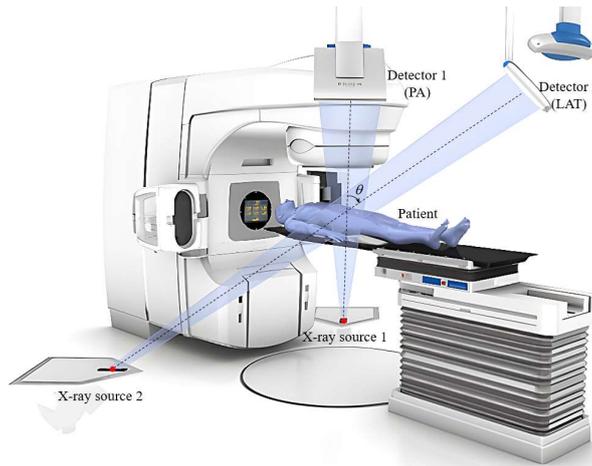


Figure 1. Schematic illustration of an IGRT system that acquires two X-ray images to monitor patient positioning during radiation treatment.

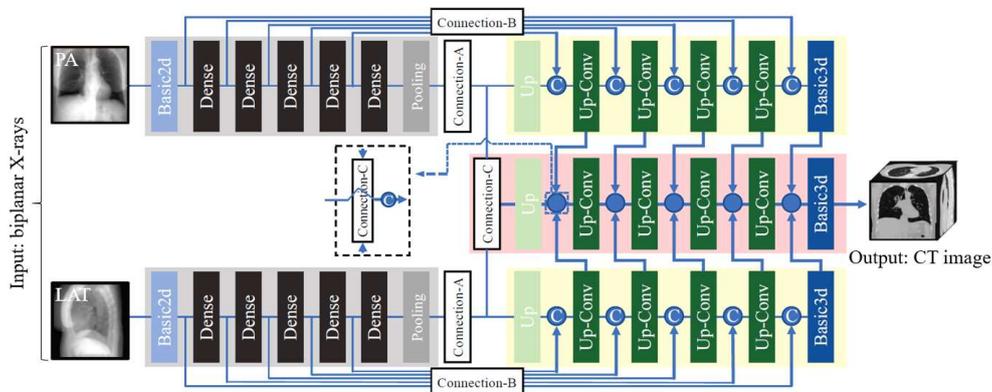


Figure 2. Architecture of the X2CT-GAN generator. Two parallel encoder-decoders process PA and LAT X-rays, with a fusion network integrating features from both views.

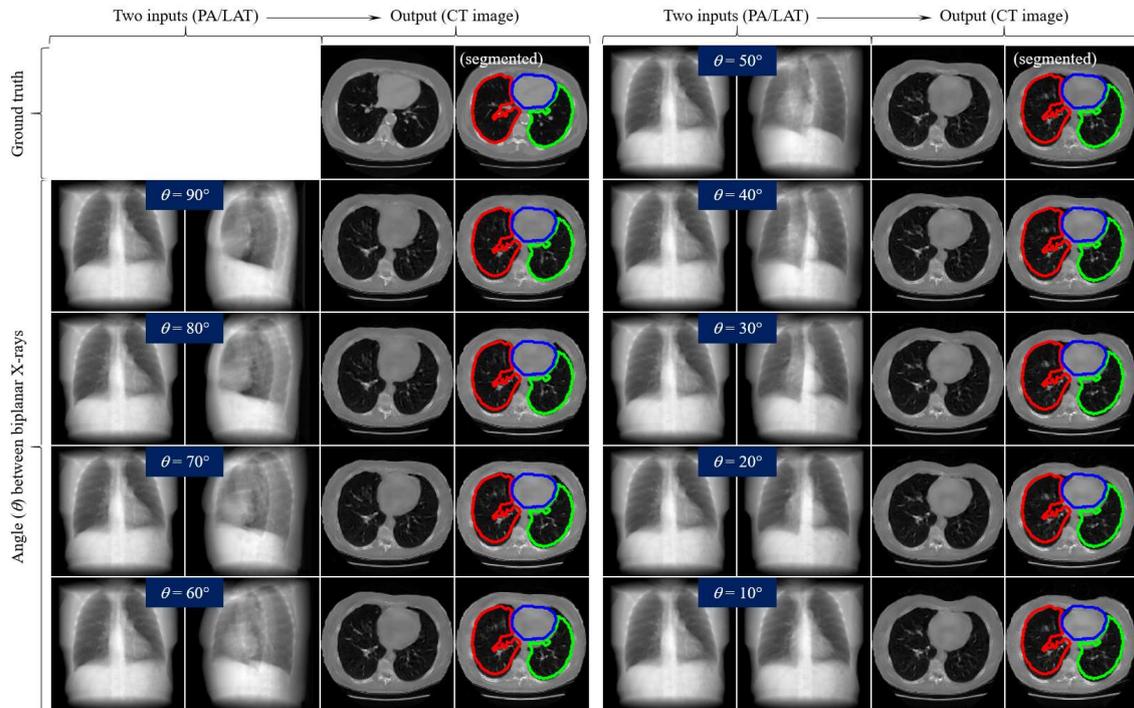


Figure 3. Preliminary CT image results obtained using biplanar X-rays acquired at various angles ($\theta = 10^\circ$ – 90°): two input images (PA and LAT) and the resulting CT output.