标题：Anatomy-aware Unified Model for MR-imaging-only Radiotherapy

详细描述：

In radiation therapy, Magnetic Resonance Imaging (MRI) and Computed Tomography (CT) are two commonly used imaging techniques. MRI offers superior soft tissue contrast, making it particularly advantageous for tumor localization and identifying organs at risk (OARs). However, MRI cannot directly provide electron density information, which is critical for dose calculations in radiation therapy. As a result, despite MRI's ability to accurately delineate tumor boundaries, an additional CT scan is typically required in clinical practice to supply the electron density data necessary for dose calculation. This not only increases the patient’s exposure to radiation but also adds complexity to the image registration process and the overall clinical workflow. To address these issues, methods for generating synthetic CT (sCT) images from MRI have been proposed to reduce reliance on CT scans. However, most existing sCT generation approaches are based on region-specific models, such as separate models for the brain or pelvis. These approaches are limited by the need for multiple models to process MRI data from different regions, which adds complexity and computational burden to clinical workflows, thereby restricting the broader application of MRI alone in radiation therapy.

To overcome these challenges, we have designed a prompt-driven unified generation model that incorporates a region-specific attention mechanism (RSAM) for multi-region MRI-to-sCT conversion. RSAM introduces region-specific prompts dynamically, enabling the model to focus on features of specific regions and ensure anatomical consistency and image quality across different anatomical areas. In this model, we combine prompt mechanisms with a self-attention architecture, allowing the network to process MRI data from various regions such as the brain, pelvis, and abdomen in a unified manner and generate corresponding sCT images. Compared to existing approaches that rely on separate models for each region, this unified model significantly simplifies the clinical workflow and improves computational efficiency.

We evaluated the performance of this model through experiments on multiple public datasets, including those for the brain, pelvis, and abdomen. The results demonstrated that the model outperformed current state-of-the-art sCT generation methods in terms of Hounsfield Unit (HU) accuracy, Structural Similarity Index (SSIM), and perceptual image quality. Additionally, dosimetric analysis further confirmed the clinical feasibility of our approach, particularly in dose distribution calculations. The model was able to provide accurate dose coverage and consistent dose calculations for critical regions, which is of great importance for tumor radiation therapy.

In summary, our work presents an innovative approach that simplifies clinical workflows, reduces the complexity of radiation therapy planning, and enhances the accuracy and efficiency of multi-region MRI-to-sCT generation. This method demonstrates high reliability in practical clinical applications and shows significant potential for use in radiation therapy planning, particularly in scenarios that require precise dose distribution.