Joint Statistical Image Reconstruction for Spectral X-Ray Computed Tomography
PhD Defense

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Abstract: X-ray computed tomography (CT) is an important and effective tool in medical and industrial imaging applications. The state-of-the-art methods to reconstruct CT images have had significant development but also face challenges. The most widely available CT systems still use the single-energy CT (SECT), which is good at showing the anatomic structure of the patient body. However, in SECT image reconstruction, energy-related information is lost due to the beam-hardening effect. In applications like radiation therapy planning and dose prediction, accurate energy-related information is needed. Spectral CT has shown the potential to extract energy-related information.

Dual-energy CT (DECT) is the first successful implementation of spectral CT. By using two different spectra, the energy information can be exported by reconstructing basis-material images. A sinogram-based decomposition method has shown good performance in clinical applications. However, when the radiation dose is low, the sinogram-based decomposition method generates biased estimations. To eliminate the bias in low-dose cases, a joint-statistical image reconstruction (JSIR) method is proposed. A relative error as high as 15% in the sinogram-based decomposition method can be reduced to less than 1% with JSIR. The JSIR framework can be extended to the photon counting CT (PCCT) systems, which enables multi-energy measurements. By simulation study, JSIR can effectively reduce the bias with sinogram-based decomposition method by more than 90%.

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