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Deep Learning for Image Correction in Sparse-View Computed Tomography

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Abstract : Medical diagnosis and radiotherapy treatment planning using Computed Tomography (CT) rely on the quantitative accuracy and quality of the CT images. At the same time, requirements for CT imaging include reducing the radiation dose exposure to patients and minimizing scanning time. A solution to this is the sparse-view CT technique, based on a reduced number of projection views. This, however, introduces a new problem— the incomplete projection data results in lower quality of the reconstructed images. To tackle this issue, deep learning methods have been applied to enhance the quality of the sparse-view CT images. A first approach involved employing Mir-Net, a dedicated deep neural network designed for image enhancement. This showed promise, utilizing an intricate architecture comprising encoder and decoder networks, along with the incorporation of the Charbonnier Loss. However, this approach was computationally demanding. Subsequently, a specialized Generative Adversarial Network (GAN) architecture, rooted in the Pix2Pix framework, was implemented. This GAN framework involves a U-Net-based Generator and a Discriminator based on Convolutional Neural Networks. To bolster the GAN's performance, both Charbonnier and Wasserstein loss functions were introduced, collectively focusing on capturing minute details while ensuring training stability. The integration of the perceptual loss, calculated based on feature vectors extracted from the VGG16 network pretrained on the ImageNet dataset, further enhanced the network's ability to synthesize relevant images. A series of comprehensive experiments with clinical CT data were conducted, exploring various GAN loss functions, including Wasserstein, Charbonnier, and perceptual loss. The outcomes demonstrated significant image quality improvements, confirmed through pertinent metrics such as Peak Signal-to-Noise Ratio (PSNR) and Structural Similarity Index (SSIM) between the corrected images and the ground truth. Furthermore, learning curves and qualitative comparisons added evidence of the enhanced image quality and the network's increased stability, while preserving pixel value intensity. The experiments underscored the potential of deep learning frameworks in enhancing the visual interpretation of CT scans, achieving outcomes with SSIM values close to one and PSNR values reaching up to 76.

Keywords : generative adversarial networks, sparse view computed tomography, CT image correction, Mir-Net
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