Metal artifact correction in cone beam computed tomography using synthetic X-ray data

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Abstract

Metal artifact correction is a challenging problem in cone beam computed tomography (CBCT) scanning. Metal implants inserted into the anatomy cause severe artifacts in reconstructed images. Widely used inpainting-based metal artifact reduction (MAR) methods require segmentation of metal traces in the projections as a first step which is a challenging task. One approach is to use a deep learning method to segment metals in the projections. However, the success of deep learning methods is limited by the availability of realistic training data. It is challenging and time consuming to get reliable ground truth annotations due to unclear implant boundary and large number of projections. We propose to use X-ray simulations to generate synthetic metal segmentation training dataset from clinical CBCT scans. We compare the effect of simulations with different number of photons and also compare several training strategies to augment the available data. We compare our model's performance on real clinical scans with conventional threshold-based MAR and a recent deep learning method. We show that simulations with relatively small number of photons are suitable for the metal segmentation task and that training the deep learning model with full size and cropped projections together improves the robustness of the model. We show substantial improvement in the image quality affected by severe motion, voxel size under-sampling, and out-of-FOV metals. Our method can be easily implemented into the existing projection-based MAR pipeline to get improved image quality. This method can provide a novel paradigm to accurately segment metals in CBCT projections.