A Novel Approach to Evaluating Metal Artifacts in CT Images Considering Artifact Characteristics

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Publication date:
2024

Document Version
Publisher's PDF, also known as Version of record

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Sunday, July 21, 2024

7:00 AM - 6:00 PM

Viewable online only through the meeting app and website

Session: Imaging General Poster Viewing

Program: Poster Program

Category: Imaging General Poster Viewing (GPV)

Abstract

Purpose: Metal artifacts, such as streaks and dark fields in CT images, are due to photon starvation and beam hardening caused by metal objects. Most existing methods for evaluating metal artifacts compute the change in pixel values in the image domain, so these are vulnerable to high-frequency noise such as salt and pepper noise. We designed a new method to measure metal artifacts in the sinogram domain, considering the characteristics of metal artifacts that propagate radially.

Methods: CT scans were performed following (stainless steel) insertion at two radiation doses (80kVp, 50mA, and 120kVp, 50mA) using a human knee-mimicking phantom. Images containing metal were reconstructed with metal artifact reduction (MAR) and without MAR (non-MAR). We selected two regions of interest (ROI) of soft tissue areas. We evaluated them using existing metrics (SSIM: structural similarity, RMSE: root mean square error) and our new metric. Our approach converts the ROI images into sinograms and then computes the profile differences between metal and non-metal sinograms. All metrics were computed by comparing the images before (reference) and after metal insertion as a full-reference method. Finally, Δ (Δ = MAR/non-MAR) was computed to evaluate the metrics.

Results: The proposed method (Δ = 80kVp: 0.91±0.02, 120kVp: 0.89±0.07) performed superior to the SSIM (Δ = 80kVp: 1.00±0.00, 120kVp: 1.00±0.00) and RMSE (Δ = 80kVp: 0.90±0.08, 120kVp: 1.04±0.11). The SSIM couldn't show a change in metal artifacts under all conditions, and the RMSE showed an error at 120kVp.

Conclusion: The proposed method was more effective than existing methods in detecting metal artifacts at both doses and ROIs. Unlike existing methods susceptible to irregular image noise, our approach effectively addresses this issue by precisely quantifying artifact amplification within the sinogram.

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