# Metal artifact reduction in computed tomography using single-energy material decomposition-driven virtual monochromatic imaging

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Metal artifacts—arising from the interaction between the high-density metals and the X-ray beams—pose a significant challenge to computed tomography (CT) by degrading image quality and hindering accurate diagnosis and treatment planning. Although numerous metal artifact reduction (MAR) techniques have been proposed, none have achieved universal adoption due to their varying effectiveness, which depends heavily on the scanned object and CT system characteristics. In this study, we present a novel MAR method that utilizes single-energy material decomposition (SEMD)-driven virtual monochromatic imaging (VMI). As illustrated in Figure 1, the proposed method comprises three main stages: 1) SEMD, which separates soft and dense material components from a single-energy CT scan by analyzing attenuation length in the reconstructed CT image, 2) VMI generation, in which virtual monochromatic projections are synthesized using selectively decomposed SEMD data to enhance contrast and suppress artifacts, and 3) MAR processing, where conventional interpolation-based MAR is applied to the synthesized projections, followed by CT image reconstruction via filtered backprojection. To evaluate the efficacy of the proposed approach, we conducted simulations using a three-dimensional numerical cylindrical phantom containing various human biomaterials (Figure 2). The resulting image quality was quantitatively assessed. Figure 3 presents representative outcomes, including the reference slice image, the original metal-corrupted image, the VMI output, the MAR-corrected image, and the final image after combining VMI and MAR. Preliminary results indicate that the proposed method can significantly reduce metal artifacts in CT images. Comprehensive quantitative results and discussions will be presented in the full paper.
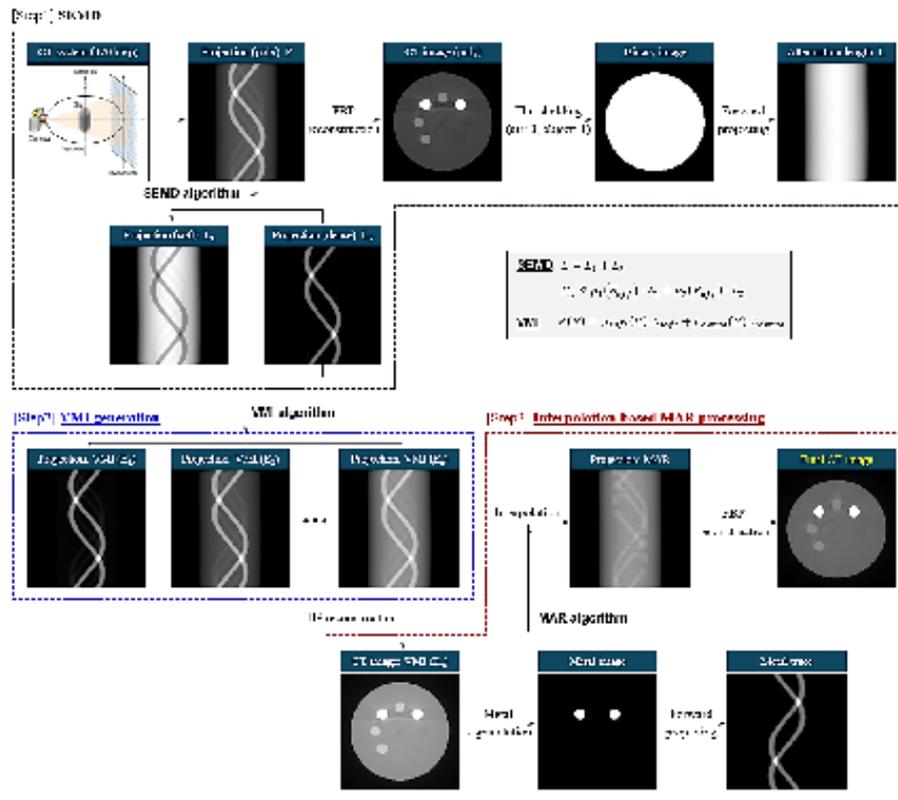
**Figure 1.** Simplified flowchart of the proposed MAR method, comprising three main stages: SEMD, VMI generation, and interpolation-based MAR processing.
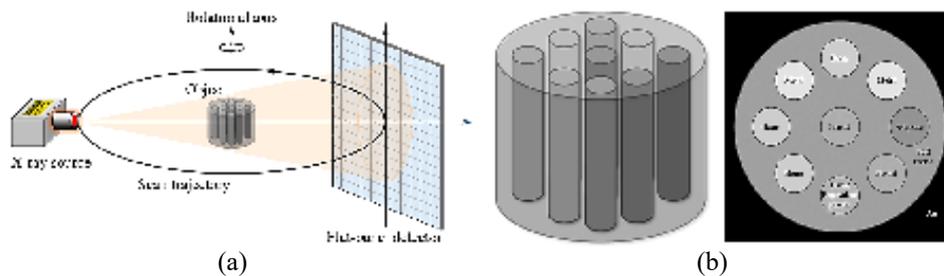


(a)                                                                    (b)

**Figure 2.** (a) Schematic of a CT scan geometry and (b) 3D numerical cylindrical phantom (200 × 200 × 200) containing various human biomaterials used in the simulation.



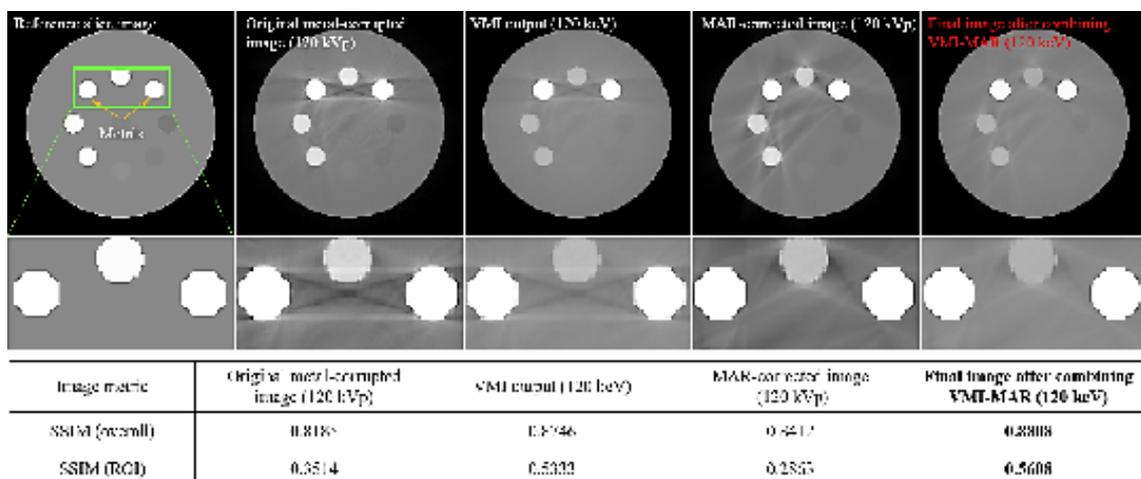| Image metric | Original metal-corrupted image (120 kVp) | VMI output (120 keV) | MAR-corrected image (120 kVp) | Final image after combining VMI-MAR (120 keV) |
|---|---|---|---|---|
| SSIM (overall) | 0.8185 | 0.8746 | 0.8417 | 0.8808 |
| SSIM (ROI) | 0.3514 | 0.5033 | 0.2855 | 0.5608 |

**Figure 3.** Preliminary simulation results: the reference slice image, the original metal-corrupted image, the VMI output, the MAR-corrected image, and the final image after combining VMI and MAR in order from left and right.