Reducing Metal Artifacts in X-ray Computed Tomography Based on Metal Effect Estimation and Multiple CT Volume Fusion

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In recent years, X-ray Computed Tomography (CT) has been widely used for assessing industrial parts. Many industrial parts often include metals, which cause various CT artifacts such as beam hardening artifacts, Exponential Gradient Edge Effects(EEGE) and metal artifacts. These CT artifacts lower the quality of X-ray CT images and prevent precise measurements. In order to reduce metal artifacts, we proposed multiple scanning and volume fusion method. Since CT artifacts are generated from metal parts in the target object, key idea of is that, we could avoid CT artifacts by changing scan angle. After the multiple CT volumes are obtained, these CT volumes are registered and fused, making optimal CT volume. Our multiple scanning method composed of involves four steps. Multiple X-ray CT scans, local CT artifacts Estimation, multiple CT volume registration, and CT volume fusion. The results of local CT artifacts estimation are considered in volume registration and fusion process. Fist, we describe local CT artifacts estimation. Since CT images are reconstructed from X-ray transmission images, unreliable region in the X-ray transmission images are the main cause of CT artifacts. Since metals in the X-ray transmission images are the most severe causes of the CT artifacts, we focused on metals. To compute effects of metals on CT volume, we extracted metal regions in the X-ray transmission images by forward projecting metal parts in the CT volume. Metal parts in the CT volume are segmented and forward projected onto virtual X-ray transmission images. Then, these metal projected images were reconstructed and CT volume data which contains metals and metal effects could be obtained. This volume data is corresponding to original CT volume and can be referred to as CT artifacts estimation data. After CT artifacts estimation is completed, we registered multiple CT volume by using modified Iterative Closest Points registration method. During surface points extraction, we excluded unreliable points by referring to CT artifacts estimation data so that we only use reliable points for registration. Lastly, registered multiple CT volumes are fused with reduced artifacts. Weights of each voxels are based on the results of the CT artifacts estimation data and used in a weighted sum to get a fused volume. To demonstrate our method, we measured several industrial parts which includes metals and resins and performed registration and volume fusion. As a result, metal artifacts in CT volume were reduced significantly compared to single X-ray CT scanning. We compared our method with other fusion method and result showed that our method is more effective to reducing streak artifacts, such as EEGE and metal artifacts.