Correction of wobble effect of a filter mounted on on-board-imager

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Abstract— **Intensity-weighted region-of-interest (IW ROI) imaging is a technique that uses X-ray illumination with two different beam intensities by mounting an intensity-weighting filter in front of the X-ray outlet. The IW ROI imaging method is a viable approach to reducing radiation dose to a patient. However, there may be potential technical problems related to a gantry motion. We mounted an intensity-weighting filter on the on-board-imager (OBI) of a Varian system, and found a wobble of the filter image in the X-ray projections. The wobble is thought to be due to gantry sagging and additional mechanical vibrations of the X-ray tube housing during the gantry rotation. The unpredictable wobble of the filter will cause image artifacts in the reconstructed image. In this work, we developed an algorithm for correcting the wobble effect by minimizing the variance of the processed data.**

Keywords— **Intensity-weighted region-of-interest, Cone-beam CT, filter, wobble**

I. Introduction

Intensity-weighted region-of-interest (IW ROI) imaging technique is a viable option of cone-beam CT for reducing radiation dose to the patients. The IW ROI method maintains a good quality image of the ROI and sacrifices the image quality of the outside ROI for dose reduction [1, 3-6]. Instead of using a conventional bowtie filter, an intensity-weighting filter is used in the IW ROI imaging. Although the bowtie filter also partly contributes to lowering radiation dose to the patient, the major purpose of using it is to improve image quality throughout the entire body. Therefore, the dose reduction effect of using the bowtie filter is fundamentally limited. We use a much heavily attenuating filter as an IW filter in place of the bowtie filter to greatly reduce the radiation dose while providing necessary data outside the ROI for stable image reconstruction.

Since the IW filter is mounted on the tube unit of the on-board-imager as shown in Fig. 1, the filter is vulnerable to motions of the tube housing including gantry sag and vibrations. As a result, the edge image of the IW filter moves in the projection images. Not only a slowly wobble possibly due to the gantry sagging but also a fast wobble of the filter were observed. This will eventually lead to image artifacts in the reconstructed images [2].

In this paper, an algorithm is proposed to correct for the wobble effect of the filter by utilizing image variance. The details about the method are explained in the following section.

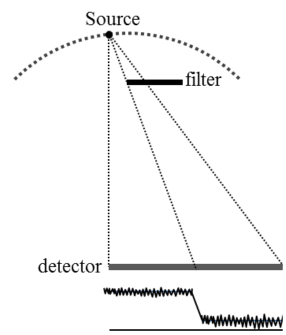

Fig. 1 A sharp transition of the intensity profile by the IW filter in a half-fan CBCT scanning configuration is shown.

II. Methods

A. System and filter

The OBI system on a Trilogy linear accelerator was used in the experiment. The scanning conditions are as following: 125kVp, 80mA and 13ms. An intensity-weighting (IW) filter made of copper was used as shown in Fig. 2.

Fig. 2 The OBI system (left) the kV source with the copper filter mounted (right).

B. Algorithm

Each step of the correction algorithm is described below.

1. Choose one projection image as a reference; add up all the rows of the image and divide it by the number of rows. We show a representative row profile in Fig. 3 (a).

2. Invert the representative row profile and multiply the maximum value of the row profile. We now refer to this

inverted row profile as an weighting function as shown in Fig. 3 (b).

3. Repeat the first step for all other views of projection images.

4. Move the weighting function along the x-axis, and multiply it by each row profile obtained in step 3.

5. Calculate the variance of each multiplied function.

6. Find location of the weighting function that minimizes the variance and apply the shift in the reconstruction.

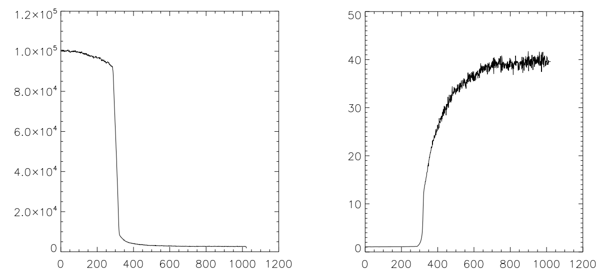

Fig. 3 A representative row profile of a projection image (left) and the plot of a derived weighting function (right) are shown.

III. Results

We made a sinogram by collecting a specific row from each view of projection images as shown in Fig. 4(a). The edge of the filter is supposed to be vertically straight in the sinogram if there were no motion of the filter. The edge image is clearly bent and shows the wobble effect of the filter. Through applying the correction algorithm, we find how much each projection image is to be shifted with respect to the reference image. We successfully corrected the edge image to be aligned straight in the sinogram as shown in Fig. 4(b), and can remove the effect of a wobble of copper filter in the reconstruction.

The image is reconstructed by the Feldkamp-Davis-Kress algorithm by using the corrected data for a flood field image and the uncorrected data for projection image [7]. (Fig. 5) A ring artifact is pronounced in the reconstructed image because of the inconsistency of the unfiltered area in each projection images.

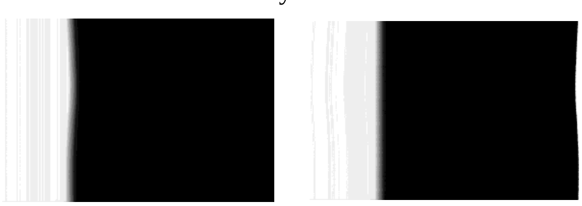

Fig. 4 Sinogram before applying correction algorithm (top) and sinogram after applying the algorithm (bottom) are shown.

Fig. 5 The reconstructed image by using the corrected data for a flood field image and the uncorrected data for projection image.

IV. Conclusions

The IW ROI imaging is a potentially very useful method for lowering the radiation dose to the patients in cone-beam CT. However, additional artifacts can be introduced in the reconstructed images including a wobble of the IW filter.

We proposed an algorithm to correct for the motion of the filter successfully. This algorithm will further help increase the quality of reconstructed image.

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