# Few-view cone-beam CT using prior image knowledge

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Low-dose cone-beam CT can be realized via several approaches including low-exposure scanning and few-view scanning. In the few-view approach, we have previously shown that one can further reduce radiation dose using prior image knowledge. In this paper, we present a comparison study between two techniques using prior image knowledge to reconstruct images from few-view data using total variation (TV) minimization algorithm. The first method uses difference data to reconstruct the difference image which eventually adds on the prior image to yield the current image, and the second method uses a masking technique to locally update the image within the masked region during the iterations. The difference image technique outperforms the masking technique in our preliminary study.

**Keywords:** cone-beam CT, low-dose CT, prior image, total variation (TV)

## 1. Introduction

Radiation dose to the patients is a major concern in cone-beam CT imaging [1]. Few-view cone-beam CT provides a viable option through which one can substantially reduce imaging radiation dose to the patients [2]. Although image reconstruction from few-view data is generally quite challenging, recent progress in reconstruction techniques promises practical utility of few-view CT in the near future. Researchers noted that there are several CT applications where repeated scans occur and prior image knowledge is therefore available to the following scans. Cho et al. [3] showed that further reduction in the number of views can be achieved by use of the prior image knowledge, and Abbas et al. [4] confirmed it using a different method. In this paper we present a comparative study between the two methods: The first method masks the image region during image reconstruction that is supposed to remain unchanged from the prior image and updates only the localized data in the iterative steps. The second method uses prior image knowledge to find the difference image projection data, reconstructs the difference image using TV minimization algorithm, and superimpose it on to the prior image after reconstruction. Comparisons were made between the two methods using numerical data.

## 2. Methods

For a numerical study, a modified Shepp-Logan (S-L) phantom was prepared through making a few changes in its ellipsoidal components. Circular cone-beam geometry was simulated, and prior image projection data sets from the original S-L phantom at 360 views were acquired. Sparse projection data were acquired using the modified phantom at 15 views on regular angular intervals.

Total-variation minimization algorithm has widely been investigated for its capability of reconstructing quality images from an incomplete data set such as sparsely sampled projections [2, 5]. The image model used is defined as below:

$$A\vec{f} = \vec{g} \tag{1}$$

Where $\vec{g}$ represents a vector of size n corresponding to projection data, $\vec{f}$ is a vector of size m and A represents the n×m system matrix. The algorithm seeks a solution that minimizes image total-variation while data consistency condition is met:

$$\vec{f_0} = argmin\|\vec{f}\|_{TV}\ such\ that\ \|A\vec{f} - \vec{g}\| < \epsilon \tag{2}$$

Where $\epsilon$ can be determined by algebraic reconstruction technique.

## 3. Results

Reconstructed S-L phantom prior image (from 360 views) is shown as in Fig. 1(a). Reconstructed modified S-L phantom images, using projection data at 15 views by implementing both difference and mask image methods are shown in Fig. 1(b) and Fig. 1(c), respectively. Both the images in Fig. 1(b) and Fig. 1(c) have no serious defects except the boundaries of the objects are not well defined as pointed by the arrows in Fig. 1(c). Fig. 1(d) shows the reconstructed reference image from 15 views without using prior image. One can see that the reference image is over-smoothened and have highlighted artifacts pointed by arrows like; boundaries of objects are not well defined (1), image is a little blurred (2) and objects are not well defined (3) .

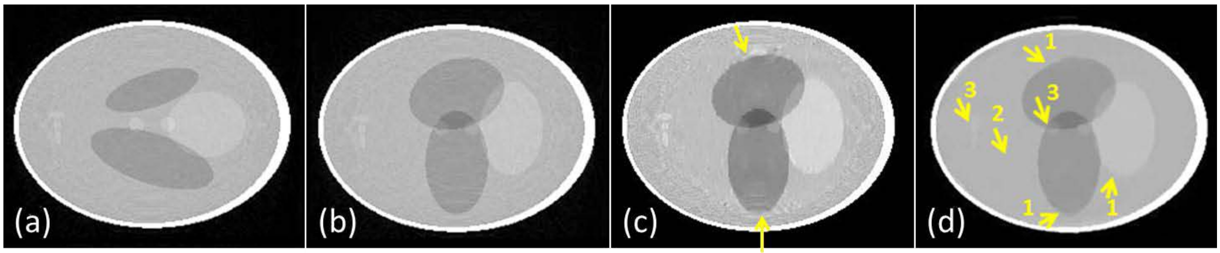


Fig. 1. Reconstructed S-L phantom images. (a) Prior image using 360 projection data. Modified phantom images reconstructed from 15 views using the difference image techniques (b) and using the masking technique (c). (d) Reconstructed image of the modified phantom from 15 views without using prior image.

## 4. Discussion

The results obtained using both techniques are quite comparable in case of numerical data analysis. Modified S-L phantom image was successfully reconstructed via difference image method as shown in Fig. 1(b). The boundaries of the objects are not well defined in the reconstructed image by use of the masking method as shown in Fig. 1(c).

## 5. Conclusion

We have successfully demonstrated that a low-dose cone-beam CT imaging can be achieved by use of the prior image with the difference image method and that it outperforms the masking method. Successful results obtained using the difference image method are thought to be due to substantial reduction in the number of unknowns compared to the masking approach ($m' < m''$).

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