

Purposes: Scatter and noise are well-known factors that degrade the cone-beam CT (CBCT) image quality. In addition to these factors, the fundamental reconstruction process adopted by most commercial systems is also imperfect. The reconstructions are mostly based on the Feldkamp formula. Such algorithm gives the accurate solution for the central slice but approximations for the remaining slices. The error increases when the slices are further away from the center due to "incompleteness" of the projection data. To combat this problem, we developed in this work a new reconstruction algorithm, which improved the CBCT image quality significantly.

Methods and Materials: The reconstruction algorithm integrated the Feldkamp formula into an iterative optimization process. For validation, a three-dimensional (3D) digital thoracic phantom was constructed based on a patient CT image and used to simulate CBCT projections. Noise and scatter were excluded from the simulation in order to isolate the basic theoretical issues in reconstruction. The projections were reconstructed with the Feldkamp algorithm, Simultaneous Algebraic Reconstruction Technique (SART), and our proposed "FDK-ART" algorithm, respectively. The images were then systematically evaluated.

Results: Artifacts became apparent for outer slices when Feldkamp algorithm was used. These artifacts were significantly reduced with the proposed algorithm. Although Feldkamp gives an accurate solution for the central slice, the root mean square error was shown to be reduced greatly by the proposed algorithm. By visual and profile comparison, it was found that the image resolution using our new method was clearly superior to that obtained with traditional Feldkamp algorithm or SART algorithm. The algorithm converged within 5 iterations for all sample cases tested.

Conclusions: A new reconstruction algorithm has been developed for CBCT imaging. The new algorithm not only reduced the errors for outer slices, but also significantly improved the image resolution and the overall quantitative accuracy for every slice.