Purpose: To develop a fast-converging SART-type algorithm and show clinical feasibility in CBCT reconstructions by combining the algorithmic enhancements with a parallel computing hardware (GPU).

Methods: SART reconstructs a volumetric image by iteratively conducting volume projection and correction backprojection. However, this reconstruction problem can also be cast as a least squares problem for minimizing the volume projection errors with respect to the scanner projection data. This way, SART can be viewed as equivalent to a gradient method for minimizing the quadratic objective function f(x), with a fixed step-size. Novelty in this work is that we implemented a simple yet much faster algorithm by computing a unique step-size at each iteration. We applied this variable step-size (VS)-SART algorithm to numerical and physical phantoms for reconstruction. Furthermore, we accelerated the reconstruction by implementing the algorithm on NVIDIA GTX 295 GPU card. CBCT projections of CatPhan phantom were acquired from the Varian TrueBeam system.

Results: We first compared SART and VS-SART using Shepp-Logan numerical phantom with 180 parallel-beam projections. As the iterations progress, f(x) is asymptotically minimized for both algorithms but VS-SART is found to converge much faster. Therefore, for a fixed number of iterations, VS-SART commands superior image quality. In addition, compared with the FDK algorithm with 364 projections, our VS-SART algorithm produces visibly equivalent quality CBCT image for CatPhan phantom with only 120 projections, in 12 iterations completed in 33 seconds. This is a factor of three dose reduction while maintaining the reconstruction time acceptable.

Conclusions: By approaching SART reconstruction problem from a gradient method perspective, we enhanced the reconstruction speed significantly (i.e., less number of iterations). In addition, with GPU acceleration, the overall reconstruction time is achieved within a clinically viable range. We anticipate that the VS-SART algorithm can be applied to CT, PET, and SPECT also.