Purpose: To study the feasibility of a novel method, CLARET (correction in limited-angle residues in external beam radiation), for supporting the Nanotube Stationary Tomosynthesis (NST) device to perform real-time deformable registration in lung IGRT.

Methods: We designed a method called CLARET that uses a machine learning strategy. CLARET is a two-step process: training and IGRT. In the training stage it performs a patient-specific training that generates sample images from a range of potential treatment deformations. Potential treatment deformations are generated from the principal variations of deformation, which are calculated between the respiratory-correlated CTs (RCCTs) and their Fréchet mean image by diffeomorphic registration. For each such sample image it generates 2D projections by re-projecting on the image volume. It computes multi-scale linear regressions between the deformation parameters and the differences between the projections of the deformed CTs and those of the Fréchet mean CT. In the IGRT stage, the learned regressions are applied iteratively to the successive residues between the radiographs and those of the current estimated CT deformed by the previously predicted parameters. This iteration yields an accurate deformation field for treatment-time 3D image generation.

Results: We tested CLARET using four patients' lung RCCTs with two types of NST geometries: 1) the single-source projection geometry and 2) the multiple-source projection geometry. For each patient and geometry a total of 40 simulated treatment-time NST projections were generated by reprojecting on the target CTs deformed from the patient's Fréchet mean RCCT. The mean and standard deviation of the tumor CoG location difference before registration is 0.6792±0.3267 cm. After CLARET registration, results in all geometries yielded sub-milimeter accuracy. The average computation time is 5 seconds.

Conclusions: We have demonstrated the potential of our CLARET method in supporting the NST device to provide real-time lung IGRT with few limited-angle projection images.

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