AbstractID: 13155 Title: Reconstruction of brachytherapy seed positions and orientations from conebeam CT x-ray projections: A novel iterative forward projection matching algorithm

Purpose: To generalize and experimentally validate a new algorithm for reconstructing the 3D pose (position and orientation) of implanted brachytherapy seeds from a few 2D conebeam-CT x-ray projections.

Methods and materials: The iterative forward projection matching (IFPM) algorithm finds the set of seed poses that minimizes the sum-of-intensity-difference-squared (SSD) of computed and experimentally-acquired auto-segmented projections of the seed array. IFPM starts with an initial approximation to the seed configuration, e.g., the pre-planned seed arrangement and then iteratively refines the 3D seed pose and imaging view-point parameters until the SSD converges. We have demonstrated the IFPM method using both synthetic projection images of clinically-realistic Model-6711 seed arrangements and measured projections of an in-house precision-machined prostate implant phantom that allows the orientations and locations of up to 100 seeds to be set to known values. The phantom was scanned using an Acuity-digital-simulator with full 660-projections. Three-to-ten x-ray projection images were selected from the conebeam-CT dataset and were pre-processed to create binary seed-only images. In addition to comparing the reconstructed to the known seed poses, 2D matching accuracy was quantified comparing the reconstructed seed projection with the measured projection using the dice-similarity-coefficient (DSC). The estimated 3D seed positions were also compared with clinically obtained VariSeed-planning coordinates derived from conebeam-CT images.

Results: For the simulations, the seed reconstruction error was better than 0.4mm/2^{o}. For the phantom experiments, IFPM absolute accuracy was (0.56±0.45)mm for position, while and (2.9±2.8)^{o} and (3.6±4.0)^{o} for polar and azimuthal angles, respectively. The DSC was better than 0.76 in each image-pair.

Conclusions: We have developed a novel algorithm for accurately recovering 3D pose of implanted brachytherapy seeds from as few as 3 projections. IFPM avoids the need to match corresponding seeds in each projection and accommodates incomplete data, overlapping seed clusters, and highly-migrated seeds.

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