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Upright CBCT: A novel imaging technique

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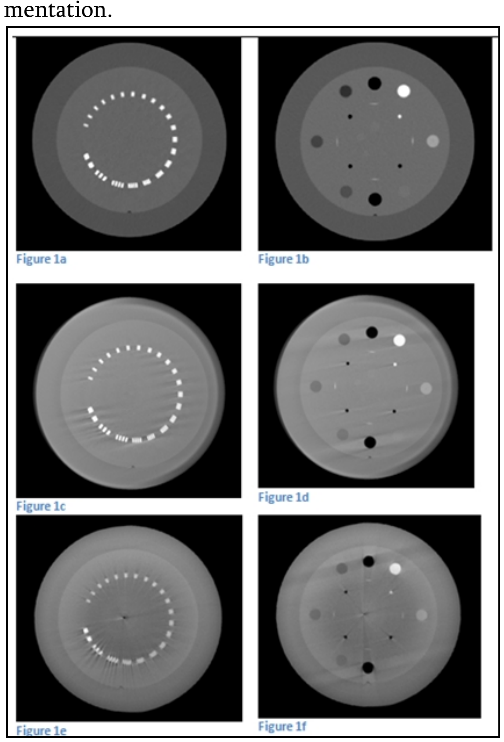
Abstract

Purpose: We present a method for acquiring and correcting upright images using the on board CBCT imager. An upright imaging technique would allow for the introduction of upright radiation therapy treatments, which would benefit a variety of patients including those with thoracic cancers whose lung volumes are increased in an upright position and those who experience substantial discomfort during supine treatment positions.

Methods: To acquire upright CBCT images, the linac head was positioned at 0 degrees, the KV imager and detector arms extended to their lateral positions, and the couch placed at 270 degrees. The KV imager was programmed to begin taking continuous fluoroscopic projections as the couch rotated from 270 to 90 degrees. The FOV was extended by performing this procedure twice, once with the detector shifted 14.5 cm towards the gantry and once with it shifted 14.5 cm away from the gantry. The two resulting sets of images were stitched together prior to reconstruction. The imaging parameters were chosen to deliver the some dose as that delivered during a simulation CT. A simulation CT was deformably registered to an upright CBCT reconstruction in order to evaluate the possibility of correcting the HU values via mapping.

Results: Both spatial linearity and high contrast resolution were maintained in upright CBCT when compared to a simulation CT. Low contrast resolution and HU linearity decreased. Streaking artifacts were caused by the limited 180 degree arc angle and a sharp point artifact in the center of the axial slices resulted at the site of the stitching. A method for correcting the HUs was shown to be robust against these artifacts.

Conclusion: Upright CBCT could be of great benefit to many patients. This study demonstrates its feasibility and presents solutions to some of its first hurdles before clinical implementation.



Simulation CT 360^0

Upright CBCT (180^0)
(125 kVp, 60 mA, 20 ms)

Extended FOV
Upright CBCT (180^0)
(125 kVp, 60 mA, 20 ms)

FIG. 1: A CatPhan phantom was imaged using the institutional parameters for a free breathing simulation CT and our new parameters for both standard FOV and extended FOV upright CBCT imaging as seen in Figures 1a-f. The resulting reconstructions were compared to evaluate spatial linearity, high contrast resolution, low contrast resolution, and HU linearity. Artifacts specific to upright CBCT imaging were also identified in the CatPhan reconstructions.

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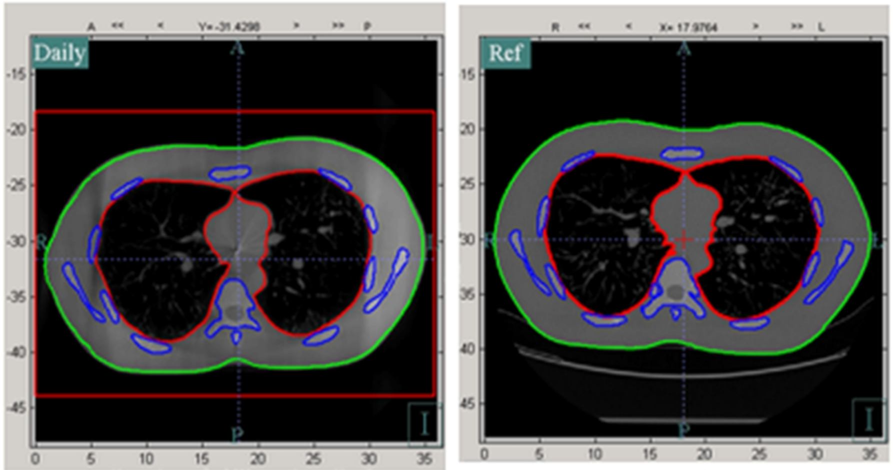

FIG. 2: The simulation CT (left) was registered to the upright CBCT (right) before deformably registering contours for the surface, lungs, and bony anatomy. This was done to show that the registration was robust to the change in HU linearity, and upright CBCT specific artifacts.

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