



Verifying Internal Target Volume using Cone-Beam CT for Stereotactic Body Radiotherapy Treatment

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Introduction:

Four-dimensional (4-D) CT images have been used to determine the internal target volume (ITV) for targets with cyclic respiratory motion. However, verifying the ITV during treatment setup is challenging, especially for stereotactic body radiosurgery/radiotherapy (SBRT) where high localization accuracy is needed. On-board cone-beam computed tomography (CBCT) provides a useful tool for ITV verification since the CBCT projection images are acquired through several breathing cycles. The purpose of this study is to assess the ability of on-board CBCT to accurately localize a mobile ITV.

Method and Materials:

A dynamic phantom with a target ball was used. The target ball is oscillated about a central reference point (zero position) by a controlling motor. An initial 3-D CT image set was taken with the target ball at the zero position. The phantom was then programmed for four different motion profiles ranging 10 - 30 mm along inferior-superior, 2 - 5mm along anterior-posterior, and 5 - 7 mm along left-right with a cycle time of 3.5 - 8 seconds. Varian RPM system was used for respiratory gating. 10 3-D image sets were generated corresponding to 10 breathing phases. The ITV was determined based on the sorted phase images. ITV was obtained from 10 sets of respiratory gated CT images. The same phantom was then placed on the linac table. An initial CBCT with no motion was acquired to register the "true" center of the ball with the planning CT. The on-board CBCT was then acquired with the mobile target ball oscillating to the same cycles in the planning CT. The ITV from CBCT was manually matched with the planning ITV to assess the accuracy of the CBCT.

Results:

The motion profiles of the 4-D dynamic phantom as acquired with the infrared camera are shown in Figure 1. The ranges of motion were 10-30 mm along SI, 2-5 mm along AP, and 5-7 mm along LR direction. The cycle time ranged 3.5-8 seconds.

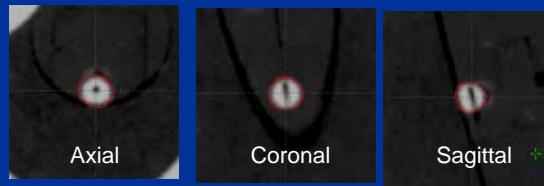


Figure 2: The GTV of the target ball staying stationary at the center of its motion.

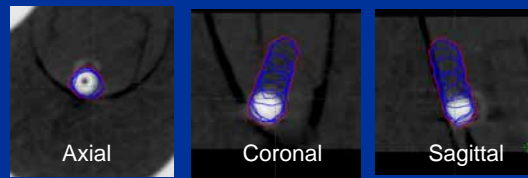


Figure 3: The ITV of the mobile target ball from the 10 phase planning CT images with motion profile #2. The blue lines are the GTV contours of each phase. The red line is the ITV by combining all the 10 GTV contours. The contrasted area on each of the image plane is the target ball. The displayed image is one of the 10 phase images.

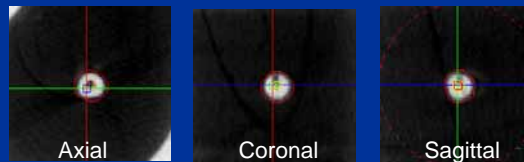


Figure 4: The GTV of the target ball at the zero position matched to CBCT.

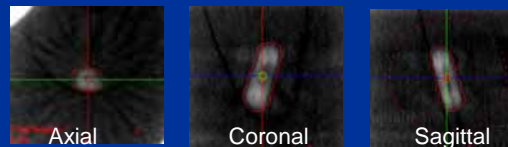


Figure 5: The ITV of the mobile target ball (motion profile #2) matched to CBCT.

Table I: Difference of the couch positions between the ITV-CBCT matching and stationary GTV-CBCT matching.

Profile #	Vertical (mm)	Long. (mm)	Lateral (mm)
1	0	1	0
2	0	0	0
3	0	0	1
4	0	1	0

Table II: Volume comparison between ITV and CBCT targets

Profile #	ITV vol. (cc)	CBCT vol. (cc)	Ratio
Stationary	0.89	0.88	0.989
1	2.27	2.05	0.903
2	2.84	2.74	0.965
3	3.50	3.40	0.971
4	2.05	1.91	0.932

Conclusion:

For targets with respiratory motion, using the ITV-CBCT matching technique can provide accurate target localization. The localization accuracy was verified with a dynamic phantom and found to be within 1 mm when compared with the stationary target localized with CBCT.

Acknowledgement:

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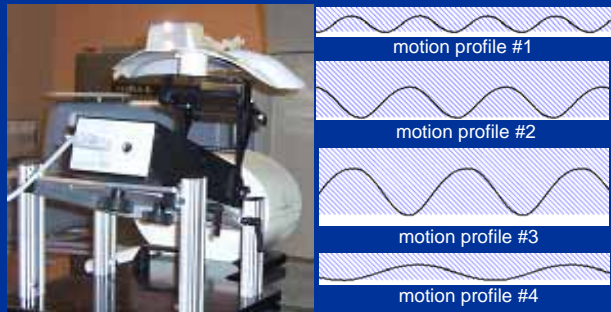


Figure 1: 4-D dynamic phantom and motion profiles.