Toward daily dose tracking for adaptive therapy: feasibility of using Monte Carlo dose calculation on corrected CBCT images


1 MIM Software Inc., Cleveland, Ohio, United States
2 RBS Evolution, Pleasant View, TN, United States
3 Hong Kong Sanitarium & Hospital, Happy Valley, Hong Kong

Purpose/Objectives

Accurate dose computation on daily CBCT is needed for adaptive dose tracking of target volumes and organs at risk in the context of adaptive radiation therapy. However, CBCT intensity values do not properly match standard Hounsfield Units (HU). This negatively affects the accuracy of dose calculations performed on them. Additionally, daily CBCT images have small fields of view (FOV), which may obscure anatomy that needs to be tracked during daily adaptive therapy.

This study evaluates a slope-intercept model for correcting CBCT HU intensities in order to calculate dose directly on daily CBCT images. This approach is intended to improve the accuracy of daily dose tracking as either a standalone correction method or a part of a larger correction process.

Materials/Methods

A planning CT (pCT) and a CBCT acquired close in time to the pCT (mean 6 days; range 2 to 12) were selected from 20 patients across multiple centers and treatment areas. This cohort consists of 4 head and neck, 6 pelvis, 5 thorax, and 5 abdomen subjects. To create a reference dose, the dose was calculated on the pCT using a commercially available Monte Carlo-based algorithm. For the CBCT correction method, the CBCT intensity values were adjusted by modifying the rescale slope and intercept for all voxels in the body. The corrected CBCT was then deformably stitched with the pCT by deforming the anatomy on the pCT to the anatomy on the CBCT in the proximity of the CBCT FOV. All deformable registrations were performed using a commercially available multi-modality deformation algorithm.

The original plan was transferred from the pCT to the deformed merged pCT/corrected CBCT. Doses were calculated on all test series using the same Monte Carlo-based algorithm. DVH statistics were calculated on target and avoidance structures for the reference series and the test series. The regional dose mean and max absolute differences were calculated and then averaged for each treatment area. Gamma was evaluated with both 2%/2mm and 3%/3mm criteria for all patients. The volume was divided into high and low dose regions using a threshold of 15% of the max absolute differences were calculated and then averaged for the reference series and the test series. The volume was divided into high dose and low dose regions using a threshold of 15% of the max

Results

The DVH statistics for the target and avoidance regions in each treatment area are shown in Table 1. The abdominal avoidance region group refers to the kidneys, the liver, the bowels, the spinal cord, and the stomach. The thorax avoidance region group refers to the heart, the lungs, the esophagus, the spinal cord, and the trachea. The pelvis avoidance region group refers to the bladder, the bowels, the rectum, and the femoral heads. The head and neck avoidance region group refer to the brain, the eyes, the spinal cord, the mandible, and the parotid. The specific diseased region was not considered in the calculation of the statistics for each avoidance region group.

Summary/Conclusion

The slope-intercept model for HU correction performed well in this experiment and would be viable for daily dose tracking during radiation therapy. In addition to the ability to perform accurate dose calculation, this method also has the advantage of retaining the original CBCT anatomy on the image on which dose calculation is performed.

References


Contact Information

Nathan Lamba, Clinical Engineer
Phone: 216-455-6088
Email: nlamba@mimsoftware.com