A rigid phantom for comprehensive end-to-end evaluation of online adaptive radiotherapy systems

VANDERBILT UNIVERSITY
CTTC Center for Technology Transfer & Commercialization

Summary

There is currently no radiotherapy phantom capable of quantitatively assessing all components of an online adaptive radiotherapy (online ART) system in a comprehensive end-to-end test.

Represented here is a novel, rigid phantom that can simultaneously evaluate an online ART system's image acquisition, deformable image registration, contour propagation, plan re-optimization, dose calculation, and beam delivery in a single process that is robust, quantitative, and convenient.

Addressed Need

Online ART promotes the integrity of the radiation dose distribution delivered to the patient even in the presence of variations in patient positioning and anatomy. Every treatment unit capable of performing online ART must be individually commissioned and validated prior to clinical use. This processes standardly includes an end-to-end verification test that simultaneously evaluates the performance and interoperability of all system components. Components required for online ART include those for image acquisition, deformable image registration, contour propagation, plan re-optimization, dose calculation, and beam delivery.

Currently, no phantom exists that can physically represent multiple morphological configurations and can also measure the delivered dose in order to quantitatively evaluate all system components in a single procedure.
The described phantom provides a convenient solution for conducting a comprehensive, end-to-end evaluation of an online ART system.

Technology Description

The described phantom has a phantom body that contains multiple test objects. The objects approximate common anatomic and treatment configurations. The precise, quantitative, morphological relationship between the objects are known completely. Rotating or replacing part or all of the phantom has the effect of replacing one object with another, simulating a specific change in an object's size, shape, and/or position. In addition, various radiation detectors such as film and ion chambers can be placed in or around the objects to measure the dose physically delivered to the phantom. As a result, this phantom is uniquely capable of achieving multiple configurations with precisely controlled changes in morphology, while also physically measuring the delivered dose, such that all system components can be assessed quantitatively through a convenient and intuitive process.

Technology Development Status

A prototype of the phantom has been designed, manufactured and tested on an existing online ART system.

Intellectual Property Status

A provisional patent application has been filed.

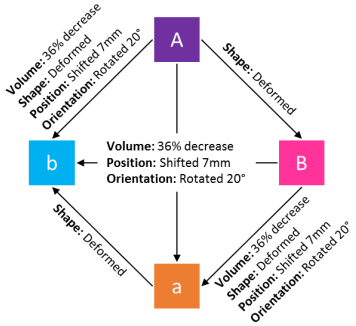

Figure 1: Schematic of the precise morphological relationships between test objects.

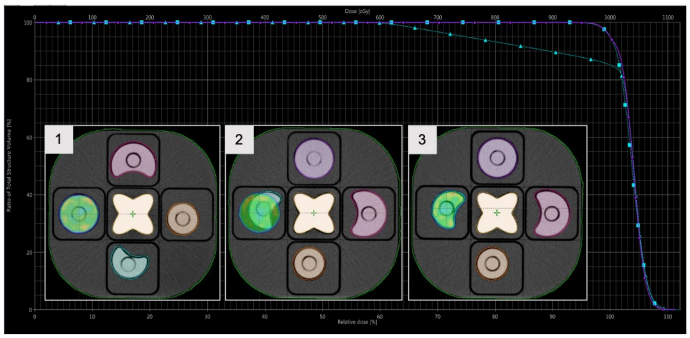

Figure 2: Dose distributions and Dose-Volume Histogram curves of 1) the original treatment plan on the original morphological configuration (DVH: purple dots), 2) the original treatment plan on the second morphological configuration (DVH: cyan triangles), and 3) the adaptive plan re-optimized on the second morphological configuration, matching the intent of the original treatment plan (DVH: cyan squares).

CTTC CONTACT:
Masood Machingal, PhD
(615) 343-3548
masood.machingal@vanderbilt.edu

INVENTORS:
Adam Yock, PhD; Abby Dare, MS; Michael Price, PhD
Department of Radiation Oncology at VUMC

VU REFERENCE: VU 20088

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