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A Deformable Lung Motion Phantom

Summary

Motion caused by patient breathing can limit the accuracy of the prescribed dose delivered during radiation therapy (RT) especially for cancers in the thorax and abdomen. Sophisticated respiratory motion prediction and real-time motion modeling have been clinically implemented to improve the accuracy and precision of the dose being delivered to a moving anatomy and minimize undesirable dosing to adjacent healthy tissues or critical organs at risk. These techniques often employ external and/or internal markers that serve as surrogates for the tumor position. Routine quality assurance of these systems are performed using programmable motion phantoms that attempt to mimic the anatomical changes during respiration as closely as possible. These current phantom designs use a rigid exterior with either a rigid or a deformable interior. However, these do not adequately model respiration as the human thorax deforms internally and externally during natural breathing. To address the limitation of current models, UMB researchers have designed and validated an anthropomorphic lung motion phantom that can be programmed with mathematical or patient-derived motion trajectories to simulate true respiratory motion on a patient-specific level for improved RT treatment plans.

Key Investigators
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Field
Radiation Oncology

Technology
Lung motion phantom

Advantages
Models natural breathing with more accuracy than current techniques

Programmable, allowing customization for individual patients

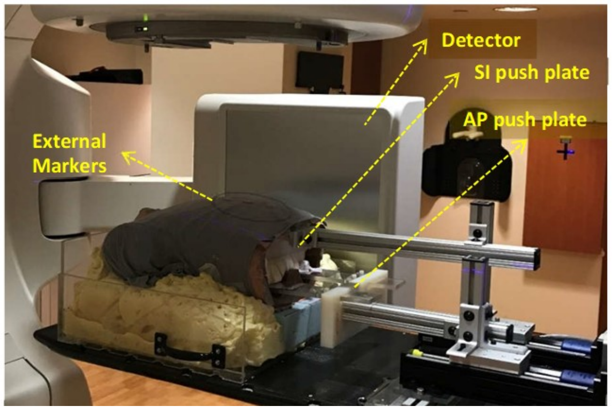
Patent Status
US Patent Pending

UMB Docket Reference
AS-2018-044

External References
Cheung and Sawant (2015) *Med Phys.* 42(5):2585-93.

Technology

This anthropomorphic lung model is comprised of a commercially-available lung outer shell and a UMB-designed lung insert made from natural latex foam. Internal and external radio-opaque fiducial markers are incorporated to serve as the surrogates for real-time motion tracking. To simulate respiration, an anterior-posterior (AP) apparatus consists of two flexible Plexiglass strips at the posterior of the phantom, oriented along the superior-inferior direction that interact with AP push plate and two independently programmable linear motion actuators- one coupled via a push plate to the lung insert to generate primarily superior-inferior (SI) motion and the other coupled via the AP push plate to the Plexiglass strips to generate primarily anterior-posterior motion (figure). The actuators are programmed to accurately represent varying amounts of engagement of thoracic and abdominal muscles from one breath to another. The presence of two independent, programmable actuators allows the user to reproducibly change the external to internal correlation of the deforming volume and also change the amplitude of the AP and SI motions to accurately represent varying amounts of engagement of thoracic and abdominal muscles from one breath to another.



Market

Radiation therapy is the most common treatment for cancer and it is estimated that 50% of all cancer patients will be administered radiation as part of a personalized treatment plan. The increasing prevalence of cancer as well as the rise in RT technologies and treatment planning capabilities are driving the expansion of the radiation oncology market, which includes the use of anthropomorphic phantoms to tailor treatment for individual patients and improved QA. Some of the companies in this space are: Computerized Imaging Reference Systems, Modus Medical Devices, Radiology Support Systems, Capintech, and Integrated Medical Technologies. Thorax phantoms range in price from $9,000 to $35,000.

Technology Status

This design is an improvement on a previously generated lung model with a single motion actuator (Cheung and Sawant, 2015). It has been validated with both mathematical and patient-derived tumor traces.

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