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Surrogate-Based Prediction Model for Real-Time Tumor Monitoring during Radiotherapy

Key Investigator
Warren D'Souza, PhD, MBA

Fields
Radiotherapy
Medical imaging

Technology
Method for monitoring tumor motion

Status
Available for licensing

Patent Status
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UMB Docket Reference
WD-2010-069

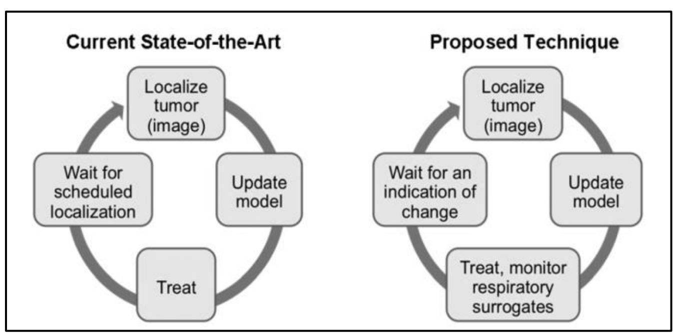
External References
Malinowski, K., et al. (2012) *Online monitoring and error detection of real-time tumor displacement prediction accuracy using control limits on respiratory surrogate statistics.* Med Phys. Apr;39(4):2042-8

Malinowski, K., et al. (2013) *Maintaining tumor targeting accuracy in real-time motion compensation systems for respiration-induced tumor motion*. Med Phys. Jul;40(7):071709.

Summary
To ensure tumor-targeting accuracy over the course of radiation treatment while minimizing the dosimetric impact to healthy tissue, respiratory surrogate models are utilized to monitor tumor position while compensating for tumor motion. These models are developed from a training dataset of concurrent tumor positions and surrogate measurements. The relationship must remain constant for duration of treatment for accuracy; however, the accuracy degrades over time due to intrafraction changes in the tumor-surrogate relationship. Methods to improve the model accuracy during the delivery of a treatment fraction have concluded that errors can be reduced with frequent model updates (i.e. more/frequent imaging) but are not practical given the increase in exposure to nontherapeutic radiation and treatment time due to additional acquisitions. The present invention is a novel method for continuously monitoring a respiratory surrogate model of tumor motion through *exclusive analysis* of respiratory surrogate measurements.

Market
Despite best treatment planning efforts, there remains a difference between the planned and actual dose delivered, giving rise to image-guided radiation therapy (IGRT). Tumors in the abdomen and pelvis are subjected to the most variation in position, primarily due to respiratory motion or organ filling. This includes tumor sites such as the lung, liver, prostate, and breast. When combined, these cancer types account for approximately 675,000 new cases each year. 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 cost of radiotherapy varies considerably, with the median cost for a course of radiation per patient at $8,600. Intensity-modulated radiation therapy (IMRT), stereotactic radiation therapy, and proton therapy can cost significantly more than standard conformal radiation therapy. Given the increasing cancer incidence and aging population, the External Beam Radiation Therapy (EBRT) market is expected to reach $6.7 billion globally by 2019. Further, it is projected that the IGRT market will grow at a stronger pace than the overall radiation therapy market.

Technology
The present invention is a novel, knowledge-based technique for timing image acquisitions used to update respiratory surrogate tumor motion models by relying *exclusively* on external surrogate measurements. This prospective, surrogate-based model is based on evaluating Hotelling's T^2 statistic and the input variable squared prediction error, $Q^{(X)}$, for predicting the accuracy of tumor localization. This approach can predict whether tumor localization error exceeds 3 mm with 95% sensitivity and 15% specificity. Using this technique, whether the real-time tumor displacement prediction is occurring under conditions described by the model could be determined. Thus, the quality of the model can be monitored without stopping treatment to explicitly measure the tumor position. Respiratory surrogate monitoring through T^2 and $Q^{(X)}$ can detect increases in residual motion during the treatment, allowing the clinicians to pause treatment to collect images when necessary to ensure that tumor motion is in accordance with the internal margin for the plan. This method can be extended to other tumor displacement inferential approaches to minimize the imaging frequency of existing systems, thereby decreasing treatment interruptions and overall patient in-room time. This method also has the potential to increase the targeting accuracy of any real-time motion compensation device, including radiation gating systems.



Contact: Rebecca Bettes, MS, MBA
rbettes@umaryland.edu
410-706-6631

University of Maryland, Baltimore
620 W. Lexington St., 4th Floor
Baltimore, MD 21201