AbstractID: 13368 Title: Real-time 3D target position estimation using a single kV imager combined with an external respiratory monitor during arc and static beam delivery

Purpose:
To experimentally investigate a real-time 3D target position estimation method, using a single kV imager combined with an external respiratory monitor, integrated with a DMLC tracking.

Method and Materials:
The experimental DMLC tracking system employed a Varian Trilogy with kV imager and Respiratory Position Management (RPM). The internal/external correlation between 3D target position $\mathbf{T}(t)$ and RPM signal $R(t)$ was modeled by a state-augmented linear model: $\mathbf{T}(t)=\mathbf{a}*R(t)+\mathbf{b}*R(t-\tau)+\mathbf{c}$. The model parameters were determined by solving least-squares estimation of the error $\Sigma\|\mathbf{p}_i - \mathbf{P}(\theta_i)\mathbf{T}(t_i)\|^2$, where $\mathbf{p}_i$ was the projected marker positions in kV images and $\mathbf{P}(\theta_i)$ was the projection operator at the gantry angle θ_i. During arc and static 5-field beam delivery, DMLC tracking was performed with ten patient lung tumor motion traces. A 3D motion stage with a gold marker and a separate 1D motion stage with an RPM marker-block were used to reproduce the tumor motion and external respiratory signals, respectively. The gold-marker positions were measured by 1-Hz kV imaging, while the external marker positions were measure by RPM system at 30Hz. To initialize the correlation model rotational kV images over 120° of angular span were acquired. The estimated 3D marker positions were sent to the DMLC to reposition the beam. The tracking accuracies were quantified as “beam-target” alignment mismatch in cine MV images acquired during the experiments.

Results:
With tracking, the average errors of the ten lung tumor traces were 0.6-1.4mm and 0.8-1.5mm during the arc and static 5-field beam delivery, respectively. Without tracking, the average errors were 3.7-6.1mm and 3.0-7.3mm.

Conclusion:
The DMLC tracking system integrated with a new estimation method shows typical accuracy of 1mm for patient tumor motion traces during arc and static delivery, and thus has the potential for accurate motion management of thoracic and abdominal tumors.

Conflict of Interest:
Supported by NIH/NCI R0193626.