

Purpose: To develop a Hidden Markov Model (HMM) of tumor motion behavior for use in adaptive image-guided radiation therapy (IGRT) to overcome the beam delivery system's inherent mechanical and imaging-rate latency. As input to the HMM we investigated clinically defined parameters and tumor motion characteristics. **Method and Materials:** Motion data from 43 lung tumors were collected by tracking an implanted fiducial using a fluoroscopic real-time tracking system. Data on a total of 1297 radiotherapy fractions were collected and for 637 fractions a convex hull was created over the data points for three consecutive breathing cycles. Statistical analysis led to the removal of outlier points, then the volumes of the hulls were calculated and their shapes visually examined. Tumor location in the lung as defined by bronchial segments was related to the volume and shape of the tumor movement envelope. **Results:** Outlier points were removed based on data density and tumor velocity limits. It was found that tumors located in the upper apex had smaller volume of movement envelope ($<50 \text{ mm}^3$), whereas tumors located near the chest wall or diaphragm were larger ($>70 \text{ mm}^3$). Tumors attached to fixed anatomical structures had a small volume of movement envelope ($<30 \text{ mm}^3$). Three general shapes described the tumor motion envelopes. Envelope volume and shape was inter-fractionally consistent. Fifty percent of tumors exhibited largely 1D oscillation; Thirty-eight percent of tumors had motion enclosed by an ellipsoid envelop with few data points in the center region, six percent of tumors moved in an arc-like defining a concave shaped movement envelope, and six percent defined a movement envelope that was of hybrid shape. **Conclusions:** The location-space correlation and the inter-fractional consistency of the movement envelope shapes will, in part, inform the development of a HMM to predict lung tumor motion for real-time beam adjustments in IGRT.