

AbstractID: 13872 Title: State Based Motion Tracking and Prediction Using a Hidden Markov Model

Purpose: To evaluate the effectiveness of a probabilistic mathematical model at tracking and predicting respiratory motion gated and motion compensated in radiation therapy. **Method and Materials:** A previously recorded set of fiducial marker positions were recorded at 30Hz for four patients and modeled into finite states representing the natural breathing states of Exhale, Inhale, and End of Exhale. State sequences and observables representing those sequences were analyzed using a hidden Markov model (HMM) to predict a future set of sequences and new observables. Velocities and other parameters were clustered using a k-means clustering algorithm to associate each state with a set of observables such that a prediction of state would enable a prediction of velocity. Positional results were then compared to several other published predictive models in terms of their overall RMS errors from actual position. System delay times from 33 to 1000 ms were considered and for additional comparison, a simple time average model which bases future sequence prediction on average past state lengths was also computed. State sequences which are known *a priori* to fit the data were fed into the hidden Markov model prediction algorithm to set a theoretical limit of the predictive power of the model at ~20% of the motion amplitude. **Results:** RMS errors for motion traces modeled by the hidden Markov model show improvement over linear and phase shift type prediction models at latencies higher than 500 ms, but do not reach the target lower limit. RMS errors for the time average model approach the theoretical limit of the HMM, even though their state sequences are poorly correlated with sequences known to fit the data. **Conclusion:** Hidden Markov models and their simpler probabilistic counterparts show much promise for use in online prediction of tumor motion for improved accuracy of radiation delivery.