AbstractID: 7524 Title: Accurate prediction of intra-fraction motion using a modified linear adaptive filter

Purpose: To predict tumor position in order to compensate for temporal latency of a target tracking-based dynamic radiation dose delivery system.

Method and Materials: A linear adaptive filter was trained for real-time prediction of tumor target position. Signal history was first filtered by a low-pass filter (LPF). Template matching was used in order to select training examples that were closest to the current case, using the distance metric:

$$D^j = \sum_{i=1}^{N} (x_i^j - x_i)^2$$

where,

D^j = distance between j^{th} training example and test case

x_i^j = i^{th} component of j^{th} training example

x_i = i^{th} component of test case.

This algorithm was applied to 160 3D tumor motion datasets acquired from 46 patients. Algorithm parameters were selected through a comprehensive sensitivity analysis performed on 10% of the datasets that exhibited maximum peak-to-peak motion. The resulting parameters were used to analyze algorithm performance over the remaining 90% of the datasets. Root mean square (RMS), maximum, mean and standard deviation of errors with and without prediction were calculated. The error distribution was tested against a Gaussian distribution using the Kolmogorov-Smirnov (KS) test.

Results: Sensitivity analyses showed that a third-order Butterworth LPF having cutoff frequency of 2 Hz was the most suitable. Examination of error indicates that it has close-to-zero mean for all the three dimensions and standard deviation is of the order of 0.1 mm. Moreover, the D-statistics of KS test are close to 0.1 (indicating a distribution that closely approaches a Gaussian) except for cases where tumor motion itself is very small (less than 5 mm). Compared to no prediction, the algorithm reduced RMS and maximum errors, on average, by 74.58% and 55.39% respectively.

Conclusion: We have developed a robust and highly efficient algorithm for predicting respiratory tumor motion. Future work includes integration of the algorithm with the laboratory setup of a dynamic MLC-based target tracking system.