AbstractID: 8969 Title: Multi-Dimensional Prediction of Respiration Motion

Purpose: The purpose of this study was to develop a technique to dynamically predict tumor position and uncertainty in three dimensions in real time.
Methods and Measurements: A novel multi-dimensional time delay kernel regression (MD-TDKR) technique was developed to predict motion up to 1.5 seconds into the future. This technique uses historical data and the correlations between the multiple dimensions to predict target position, and allows for continuous memory updates to dynamically retrain the model. This technique could be used in a variety of motion prediction applications.
Results: In one example, the algorithm inaccurately predicted tumor position, but was able to identify the corresponding uncertainty increase. When the model was unable to accurately predict position, the 95 percent uncertainty interval becomes quite large. Likewise, the predictions are accurate where the uncertainty is small. This information can be used in determining when to temporarily trigger the beam on-and-off. The average percent error was computed at different latencies. For predictions 1.5 seconds into the future the error was 7.83%, for 1 second it was 6.55%, and for 0.5 seconds it was only 5.27%. The average uncertainty for the predictions at 0.5, 1, and 1.5 seconds into the future was 4.99%, 6.18%, and 7.12%, respectively.

Conclusions: This study shows that MD-TDKR can learn complex relationships in multidimensional respiration data. Because of its ease of building and updating the memory matrix, the model can adjust to new operating conditions, such as changes in a patients breathing pattern. It was also able to determine the uncertainty for a given query vector, allowing for the ability to hold the beam off when the prediction is unsure. These factors indicate that MD-TDKR has great potential for use in radiation oncology. It is also anticipated that the MD-TDKR paradigm could be easily implemented into commercial respiratory gating systems.