Purpose: Prediction methods for breathing patterns, which are crucial to deal with system latency in treatments of moving lung tumors using state-space methodologies based on non-linear dynamics are contrasted to linear predictive methods.

Method and Materials: In our previous work we established that breathing patterns can be described as a 5-6 dimensional nonlinear, stationary and deterministic system that exhibits sensitive dependence on initial conditions. In this work, nonlinear prediction methods are used to predict the short-term evolution of the respiratory system for 3 patients. Single step and N-point multi step prediction are performed for sampling rates of 5Hz, 10Hz, and 30Hz. We compare the employed non-linear prediction methods with respect to prediction accuracy to Infinite Impulse Response (IIR) prediction filters. The simplest form of local prediction is finding similar segments of scalar time series data in a higher dimensional embedding space. Hence, we predict the future value $x(t)$ of N-time steps ahead by simply finding the average of nearest neighbor points to the point $x(t)$ in the past and using them to estimate $x(t+N)$, yielding a local average model (LAM). Local linear models (LLM) which are linear autoregressive models that hold only for a region around the target point formed by the nearest neighbor points is combined with a set of linear regularization techniques to solve ill-posed regression problems are also implemented.

Results: For all sampling frequencies, both single step and N-point multi step prediction results obtained using LAM and LLM with regularization methods are better than IIR prediction filters for the selected sample patients.

Conclusions: The use of non-linear prediction methods for predicting the breathing pattern of lung cancer patients may lead to improved, robust and accurate long-term prediction to account for system latencies.