# AbstractID: 10885 Title: Real-time profiling of respiratory motion and its application to continuous horizon prediction


Purpose: Respiration-induced tumor motions are semi-periodic and exhibit different variations that have distinct clinical implications. We develop and investigate a system that is capable of estimating baseline drift, frequency variation and fundamental change (oscillatory amplitude and shape) in real time and utilize such information to predict abdominal or thoracic tumor positions.

Method and Materials:The observation is modeled as a periodic fundamental pattern modulated in both frequency and baseline, which is subsequently corrupted by independent additive noise. To jointly estimate these coupled components online, we utilize three key techniques : (1) augment state to capture system dynamics and hysteresis; (2) create a low order elliptical shape model to characterize semi-periodicity; (3) perform Poincare sectioning to automatically identify iso-phase instances. Linear interpolation/extrapolation from iso-phase points provides a continuous phase warping function. The baseline drift is obtained by projecting the elliptical center onto the original time-displacement axis. A least squared error (LSE) estimate for the fundamental pattern is obtained by inversely phase- warping the observed trajectory and compensating for the mean drift. The proposed method is applied to simulated data with known "ground-truth". In a preliminary prediction test with RPM data, each component (baseline, phase and fundamental pattern) is extrapolated respectively, and then reassembled to provide a "predicted trajectory".

Results: The proposed method provides the first unsupervised system that achieves robust real-time estimation of mean displacement, phase and fundamental pattern. Application of the online profiling system to prediction yields continuous horizon prediction of 3~5 seconds, with similar behavior to what is expected from human observers.

Conclusion: We have proposed an online profiling paradigm for describing and characterizing respiratory motions. Tests on simulation data and RPM signals have demonstrated the efficacy of the proposed method.



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