Abstract ID: 16082 Title: Quantifying respiratory hysteresis via an inter-cluster distance metric

Purposes: Understanding the degree of respiratory hysteresis is important for motion adaptive radiotherapy, as patients with significant respiratory hysteresis may require different motion models and/or management techniques. This work aims to develop a quantitative hysteresis index, that has the right metric property and robust towards observation settings.

Methods: The proposed method herein is a data-driven, clustering-based approach. It stems from the intuition that hysteresis manifests via the discrepancy between the inhalation and exhalation segments of the respiratory trajectory. Therefore, a semi-supervised clustering method is first applied to partition the trajectory data into inhalation and exhalation stages, and hysteresis is characterized by an inter-cluster distance metric that intrinsically associates the corresponding displacement at these two stages. This metric is designed to be robust to scale, dynamic range, and data size, to permit comparison of hysteretic behavior across datasets acquired under different observation protocols and/or modalities. In the absence of any existing objective characterization of hysteresis, the proposed index was computed for simulation data to corroborate with human judgment. The robustness of the proposed index is tested with cross-validation, applied to 159 patient-derived respiratory trajectories.

Results: The proposed hysteresis index is stable, and corroborates well with human judgment. Distribution of the hysteresis index among the patient cohort shows a small subgroup of trajectories with noticeably high hysteresis.

Conclusion: For the first time, a quantitative index for hysteresis has been proposed. It is a proper metric and reflects the insight as a measure of discrepancy between corresponding inhalation and exhalation segment. The presence of a small population with high hysteresis alludes to the potential to "differentiate" patients based on such index and customize the motion management strategy. We will continue to develop unsupervised clustering schemes with built-in outlier detection, and endeavor to incorporate physiological/biomechanical insight.

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