AbstractID: 3000 Title: Analysis of periodicity and complexity of breathing patterns for Radiotherapy

Purpose: Existing models of breathing generally use a simple modified cosine function, which poorly approximates true breathing patterns. This study pursues a more robust means of quantifying the periodicity and variation of individual breathing patterns.

Method and Materials: The problem is formulated as a multilayer optimization problem where a search over all possible periods for the "best-fit" signal is conducted. For each period within a reasonable range, a subspace of all signals with that period is constructed and the observed breathing trajectory is projected onto that subspace to obtain the closest matching periodic signal. Projections from each such subspace are then compared to yield the overall best periodic approximation. Temporal sampling is taken into account explicitly in the derivation so that the optimal period is not restricted by the sampling rate of observed trajectory. Utilizing a projection method, a closed form solution is derived, resulting in an extremely computationally efficient algorithm. Performance was assessed with clinical RPM and diaphragm trajectory data.

Results: Experiments with clinical data yield "best" periods between 3-10s for normal breathing, agreeing with physical understanding. Unlike traditional Fourier transform based approaches, fundamental patterns and approximation errors are obtained. These patterns yield a richer (yet physically sound) class of shapes than the commonly employed heuristic modified cosine. Approximation error of the optimal projection signal agrees with intuitive explanation of regularity, i.e., the error monotonically increases with the irregularity level.

Conclusions: This work provides a potential irregularity measure for periodicity that would facilitate individualized treatment planning. The approximation error serves as an index for variation in breathing pattern, and thus helps to determine the necessity of an individualized treatment plan. Understanding optimal periods and fundamental patterns of breathing would help in designing a patient/fraction dependent treatment plan.

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