

Purpose: To introduce and evaluate a new method for automatically extracting respiratory phase information directly from CBCT or tomosynthesis projection data.

Methods: In the proposed method, the Black and Anandan dense optical flow is computed in the longitudinal direction between a fixed region of interest (ROI) extracted from each projection image in a free-breathing CBCT scan and its nearest chronological neighbor. The optical flow values are integrated over time to yield a respiratory signal curve. Free-breathing CBCT projection data from several thoracic and abdominal subjects were used to compare the integrated optical flow (IOF) method with the “ground truth” signals measured by manually tracking the motion of internal anatomy landmarks (e.g., the diaphragm). Finally, phase information from the proposed technique was used to reconstruct exhalation and inhalation tomosynthesis image sets, for comparison with free-breathing tomosynthesis reconstructions of the same subjects.

Results: The proposed integrated optical flow (IOF) method yielded respiratory motion curves whose phase information agreed well with measured data. However, the IOF amplitudes showed strong chronological trends, due to changing projection geometry. Furthermore, the IOF method sometimes required an adjustment of the ROI location part-way through the scan due to the rotational motion. Phase-based tomosynthesis reconstructions using only projections near the full-inhale or full-exhale phases (as determined via the automated IOF method) exhibited the expected trends, with internal anatomy and target tumor locations clearly distinguished by phase, and often more clearly visible than in the full free-breathing reconstructions, which contain far more motion blurring.

Conclusions: The proposed IOF method is an effective way to automatically sort free-breathing CBCT projection data into respiratory phase bins for phase-based 4D tomosynthesis or CBCT reconstruction. Future work will focus on automatic relocation of the ROI and de-trending of the IOF measures using estimations from the free-breathing CBCT or planning CT.