AbstractID: 6675 Title: Cardiac-Gated Dual-Energy Imaging of the Chest: Design and Performance Evaluation of a Cardiac Trigger Based on a Fingertip Pulse Oximeter

Purpose: A research prototype for high-performance dual-energy (DE) imaging of the chest is under development. This paper discusses the development and characterization of a cardiac gating system designed to precisely trigger the imaging system according to cardiac phase and minimize anatomical misregistration due to heart motion.

Method and Materials: A fingertip pulse oximeter was employed to measure the peripheral pulse waveform and trigger x-ray exposures during the quiescent phase of the heart (diastole). Temporal delays accounted in the timing scheme include physiological pulse propagation, waveform processing, and imaging system delays (filter-wheel, bucky-grid, and flat-panel detector). An empirical model of the diastolic period allows calculation of the implemented delay, t_{imp}, required to trigger correctly at any patient heart-rate. Performance was evaluated in terms of accuracy and precision of diastole-trigger coincidence and expert assessment of cardiac motion artifact in gated and ungated DE images.

Results: The model suggests a triggering scheme characterized by two heart-rate (HR) regimes: below a HR-threshold, sufficient time exists to expose on the same heartbeat ($t_{imp} = 0$); above the HR-threshold, a characteristic $t_{imp}(HR)$ delays exposure to the subsequent heartbeat, accounting for all fixed and variable system delays. Initial implementation indicated 83% accuracy in diastole-trigger coincidence. By modifying the HR estimation method (reduced temporal smoothing of the pulse waveform), trigger accuracy of 100% was achieved. Cardiac-gated DE patient images demonstrate significantly reduced cardiac motion as assessed by expert radiologists.

Conclusion: A pulse oximeter combined with a cardiac model provides accurate x-ray triggering and significantly reduces heart motion artifacts. A simple fingertip clip presents logistic, cost, and workflow advantages compared to ECG. The system has been implemented in a clinical research trial, with gated and ungated arms allowing characterization of the impact of cardiac motion artifact on diagnostic performance.

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