Session 2 - Motion Correction (Image Generation)

8 - Ultrasound-based sensors for motion correction of PET data

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Authors

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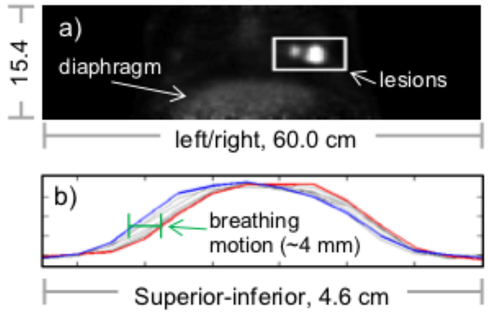
Abstract

Objectives: Breathing motion remains problematic in PET as it causes image blurring. In turn, degradations in image quality may impact treatment planning and complicate the fusion of multi-modality images. We developed small ultrasound-based sensors, referred to as 'organ configuration motion' (OCM) sensors, along with machine-learning algorithms to interpret their signals. Unlike optical tracking, the sensors directly detect motion inside the body. They are small (~3x3x1cm), cheap, reusable and provide a wealth of information about organ position. Information from these sensors was employed here to resolve the breathing cycle.

Methods: Two patients scheduled for an oncologic PET/CT exam were imaged with the sensor in place, following informed consent with an IRB-approved protocol. The research PET was acquired after the clinical scan, using the same reference CT data, with no additional radiation to the patient. Each sensor consists of a simple, inexpensive, single-element ultrasound transducer enclosed in a 3D-printed capsule of our own design. Each OCM signal 'trace' is composed of about 20,000 voltage measurements arising from echoes recorded by the transducer from many tissue/organ interfaces within the transducer's wide field-of-view; the echo signals were acquired over a period of about 0.1 to 0.2ms, and the voltage traces were repeatedly acquired during a 10-minute PET scan at a rate of 100 traces per second. As OCM and PET data were acquired and recorded simultaneously, the two data streams were synchronized using aperiodic pulses introduced into both. More specifically, we used the PC to sample OCM signals, with a BNC cable connected to a NI 5122 digitizing oscilloscope card. A USB port, on the same PC, was connected to the respiratory gating port of the PET/CT scanner through modified cables/connectors. At irregular time intervals, incoming OCM traces were identified at the same time as voltages were placed on pins of the USB port. These voltage pulses were simultaneously passed through the PET/CT respiratory trigger port, so that they could be recorded in the PET list-mode data file. As a result, a non-periodic pattern of time tags appeared in both the OCM and the PET raw data files, allowing OCM and PET data streams to be temporally aligned without ambiguity. The list-mode files were read and sorted into respiratory gates, based on OCM information. The sorted data were then written to new list-mode files, one for each respiratory phase, and reconstructed on the scanner using the vendor's software. Results: Cylindrical imaging volumes (60-cm-diam x 15.4-cm axially) were reconstructed for each patient. Simply averaging all 10 gates yielded images nearly identical to those reconstructed by the scanner at the time of the exam. Displaying individual gates, e.g., in a movie, allowed breathing motion to be visualized. In a mesothelioma patient with several lesions, some were attached to mostly-static tissues and moved very little throughout the breathing cycle while others moved over a range of 5mm or more, mostly in the superior-inferior direction. Conclusions: Inexpensive, easy-to-use ultrasound-based sensors can monitor internal motion during PET exams to help resolve and/or correct for breathing

motion.



a) Lesions can be clearly seen in the coronal plane displayed here. The ROI shown using a white rectangle was projected along the left-right direction and onto the superior-inferior axis. The resulting 1D profiles are shown in (b), for all breathing gates. Full expiration/inspiration gates are highlighted in (b) using blue/red curves, respectively. Markings in green help visualize the extend of the breathing motion, about 4 mm here.

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