Instrumentation and Data Analysis
Scientific Paper Session (Oral)
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No. 44

Real-time 3D motion tracking using MR micro-coils for PET imaging. Chuan Huang¹, Jerome Ackerman², Yoann Petibon¹, Thomas Brady¹, Georges El Fakhri¹, Jinsong Ouyang¹; ¹Center for Advanced Medical Imaging Sciences, NMMI, Radiology, Massachusetts General Hospital, Harvard Medical School, Boston, MA, ²Martinos Center for Biomedical Imaging, Massachusetts General Hospital, Harvard Medical School, Boston, MA.

Objectives: Artifacts from both voluntary and involuntary head motion are major challenges to brain PET imaging. We investigated the feasibility of using MR micro-coils to track head motion and incorporate the MR-coil measured rigid motion fields in iterative PET reconstruction.

Methods: We built MR tracking micro-coils (diameter < 5mm) that incorporate sealed doped water and built a dedicated MR sequence to measure the locations of the coils with 15ms temporal resolution. The micro-coils were attached to the surface of an 18F-filled Hoffman phantom. The rotation/translation complex motion pattern of the phantom was induced by a ventilator. PET list-mode and MR tracking data were acquired simultaneously on a PET-MR scanner. PET images were reconstructed using: 1) nMC: iterative PET reconstruction without motion correction; 2) MC: iterative PET reconstruction with the measured real-time rigid motion fields incorporated into the system matrix. Additionally, static phantom data were acquired and reconstructed as the static reference (SR). The contrast ratios were computed for two regions of interest (ROI).

Results: Compared to nMC, the motion induced artifact is dramatically reduced in the images reconstructed with MC. The contrast ratios for the two ROIs were 2.6 and 4.4 for nMC, 4.4 and 5.5 for MC, and 4.8 and 5.2 for SR. The MC yielded similar results to SR.

Conclusions: PET image quality can be significantly improved by incorporating the real-time 3D motion fields for arbitrary rigid motion measured by low-cost MR tracking micro-coils.

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Abstract:

A completed SPECT/MR insert for simultaneous SPECT/MR imaging of small animals. Benjamin Tsui, Jingyan Xu, Andrew Rittenbach, AbdEL-Monem El-Sharkawy, William Edelstein, Kevin Parnham, James Hugg. 1Department of Radiology, Johns Hopkins University, Baltimore, MD, 2Gamma Medica, Northridge, CA.

Objectives: The goal was to complete the development of a SPECT/MR insert for simultaneous SPECT-MR imaging of small animals.

Methods: The development of a 2nd generation SPECT/MR insert for simultaneous SPECT/MR imaging of small animals was completed and fully evaluated. It consists of 5 rings of 19 seamlessly connected 2.54x2.54 cm², 16x16 pixels cadmium zinc telluride (CZT) detectors. The CZT detectors directly convert incident photons into electric signals and hence are minimally affected by the static magnetic field of the MRI. Two multi-pinhole (MPH) collimators of 18 and 36 PHs were designed with 1.0 and 1.5 mm resolution, respectively. The collimators were made of a cylindrical shell filled with high density tungsten powder and solid tungsten pinhole inserts. A shielded birdcage quadrature transmit/receive RF coil was designed for mouse imaging. It fit inside the MPH collimator to maximize SNR. Accurate system calibration and quantitative sparse-view 3D MPH reconstruction methods were developed for high quality SPECT images.

Results: The measured resolutions of the both collimators agreed with their targeted system resolutions and measured detection efficiencies were 172 and 372 cps/MBq, respectively. The predicted Lorenz force effect on the CZT detectors was observed and corrected. With collimator-detector response modeling, the SPECT image resolution exceeded the target system resolution of the MPH collimators. In a simultaneous SPECT/MR phantom study, both the SPECT and the MR images showed minimum image artifacts, and the SPECT images had minimum degradation from the presence of the MRI. By using a linear birdcage coil with long RF shield, the SNR degradation in MR images was reduced to less than 50% compared to that using quadrature coil.

Conclusions: We have demonstrated the high-resolution simultaneous SPECT/MR imaging capability of the SPECT/MR insert by using phantom studies. Simultaneous SPECT/MR imaging studies of small animals are underway.

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