MR Guided Motion Correction for Yttrium 90 Imaging using a Simultaneous PET/MRI Scanner

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Introduction: Selective internal radiation therapy (SIRT) using Yttrium 90 (Y-90) is a therapeutic procedure that aims to treat patients with un-resectable liver cancer by delivering a localized radioactive dose to tumors. A fraction of the emitted Y-90 radiation decay with internal pair production results in a small but measureable signal that can be detected using positron emission tomography (PET) [1]. PET evaluation of the bio-distribution of the Y-90 microspheres has shown to be advantageous, in detection of shunting to other organs, and in dose-calculations and quantification [1]. Conventional Y-90 PET reconstruction without compensation of breathing motion may lead to blurred and inaccurate quantitative data. In this study, we developed and implemented a real time, MR-guided motion correction for Y-90 PET imaging using a simultaneous PET/MRI scanner (Biograph mMR, Siemens HC, Germany).

Methods: The range of motion of the liver was measured using a pair of end-inhale and end-exhale attenuation map images. The diffeomorphic demons non-rigid registration algorithm was applied (**figure 1**) [2]. Real time motion tracking was performed during the PET acquisition using sagittal 2D MR planes (TE=1.060 ms, TR=200 ms, 1.78x1.78 mm^2) centered at the dome of the liver [3]. The measured motion was then used to estimate the 3D motion of the liver at various breathing states. These estimates were finally used to warp the previously measured positions to generate quasi-continuous elastic motion fields. Specific breathing positions are then incorporated in the PET reconstruction with the PSF-OSEM algorithm (1 iteration and 21 subsets, 4.1x4.1x2.03 mm^3, 4 mm post-reconstruction Gaussian smoothing) [4]. Attenuation and scatter correction were also performed using a moving attenuation map corresponding to the breathing state. Phantom validation was performed using a uniform phantom injected with 407 MBq of Y-90 and scanned for 20 minutes in list-mode on a custom-built motion phantom holder. Finally, a human subject injected with 2.8 GBq of Y-90 microspheres was also scanned for 20 minutes in list-mode to validate the approach.

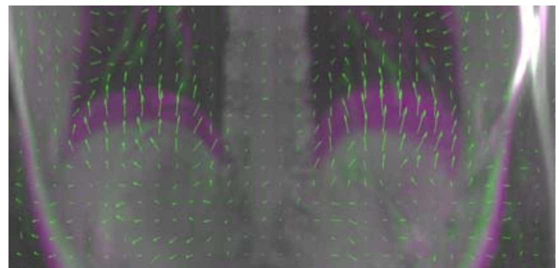

Fig 1.Sample transformation field as measured using the proposed method overlying the moving and static images.

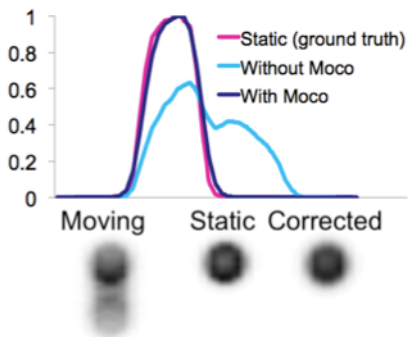

Fig 2. Top**:** Line profile across the phantom. PET image with and without motion correction as compared to the ground truth (static). **Bottom**: Motion blur is observed without correction, but is largely eliminated following motion correction

Results: Experiments conducted on the phantom revealed significant blurring and quantitative errors as shown in **Figure 2** compared to the static acquisition. Circular ROI around the phantom revealed a 48% error in quantification compared to the ground truth (static acquisition). Following motion correction, however, motion blur was reduced visually and quantitatively as shown in the line profile. In the human study, the measured motion in the head-feet direction was 1.42 cm. Uncorrected compared to the motion corrected image is shown in the **Figure 3**. Similar to the phantom findings, contrast was reduced markedly when respiratory motion was not corrected for. Conversely, motion blur was reduced following motion correction.

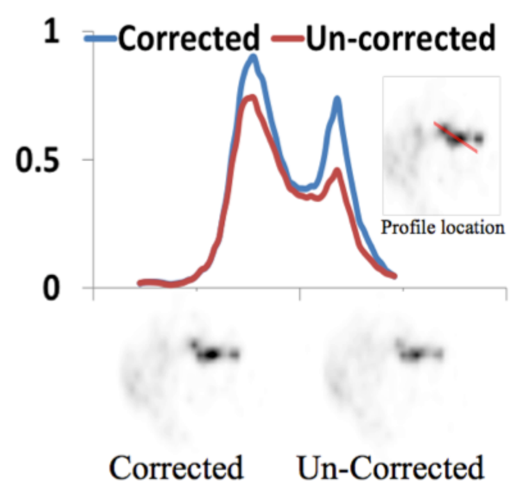

Fig3. Top: line profile across the motion corrected and uncorrected image.
Bottom: Sample Y-90 PET images.

Conclusions: MR guided motion correction was feasible for tracking motion of the liver due to respiration. This motion information can be directly incorporated into the PET reconstruction to generate motion corrected PET images.

References:

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