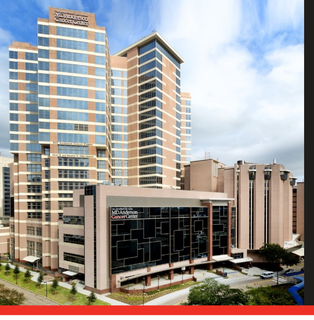

Novel Computer-Aided Detection of Respiratory Misregistration Artifacts in PET/CT

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Background

- PET/CT is a powerful diagnostic tool used for structural, functional, and molecular phenotyping of tumors at the whole-body level.
- Almost all cancer patients receive a PET/CT scan before treatment.
- PET acquires whole-body physiological data over 10-15 minutes, or 2-3 minutes per each axial slice, which averages closer to end-expiration phase than end-inspiration phase of the respiratory cycle. CT scans for anatomy and body composition in < 1 minute, or sub-seconds per each axial slice. PET and CT scans are registered once scanning is complete.
- PET/CT data is acquired in free breathing, unlike MRI or CT.
- Respiratory motion-related artifacts from the misregistration between PET and CT data causes tumor blurring and inaccuracies in tumor quantification and localization, altering the benefits of PET/CT. While actions have been taken to clinically reduce misregistration, detection is still a manual process.

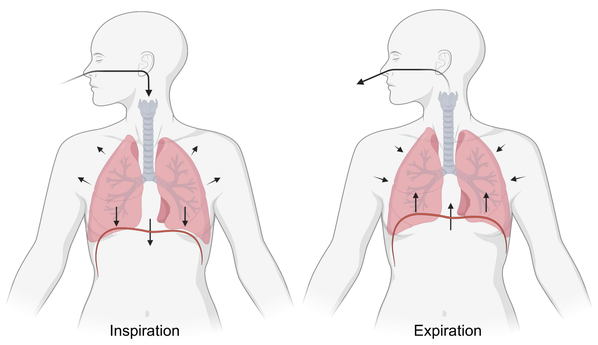

Fig. 1. During inspiration, the lung expands and the diaphragm contracts, moving down. As air is released during expiration, the lungs and diaphragm relax, moving upward. This respiratory movement affects the CT slices captured axially, causing misregistration between the PET and CT.

Objectives

- Develop a computer-aided detection model to identify if lung misregistration is present in each patient's scans.
- Use the detection model to automatically alert PET technologists of misregistration prior to patient's departure from the scanner.

Methods

Patients' scans were fed from the scanner to the computer via MIM software. Axial PET/CT slices were extracted from DICOM and reconstructed as Python arrays. Lung and body areas were calculated using Hounsfield Unit (HU) values and body contours. Misregistration was detected by measuring differences of over 10 mm between PET and CT scans in the thorax and abdomen due to breathing motion. Algorithms were designed to automatically draw whole-body line profiles through the left lung. These algorithms were tested on 20 randomly selected patients' data, each with a varying number of axial slices. The algorithm's results were compared to manually traced line profiles and CT tube current modulation trend. Using differential equations and descriptive statistics, the lung-diaphragm edge was identified in CT scans and compared with PET scans with and without Attenuation Correction (AC) to assess misregistration. The algorithms were iteratively refined for improved accuracy and tested on a larger patient cohort.

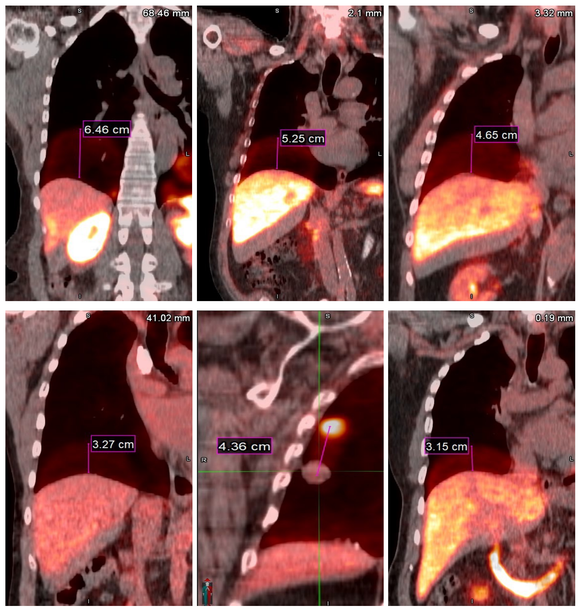

Fig. 2. Six examples of PET and CT misregistration using different tracers, visualizing that misregistration is almost always the fault of CT. Tracers are ^{68}Ga-Dotatate, ^{18}F-FCABC, ^{18}F-FCABC, ^{18}F-FDG, ^{18}F-FDG, and ^{18}F-DCFPyL, respectively.

Results

- Body area calculated using HU allowed for high sensitivity in segmenting the lungs from the rest of the body.
- Parasagittal column area per slice provided the best specificity-to-noise ratio for detecting lung misregistration in 19 out of 20 patient scans.

Prototyping a Line Profile

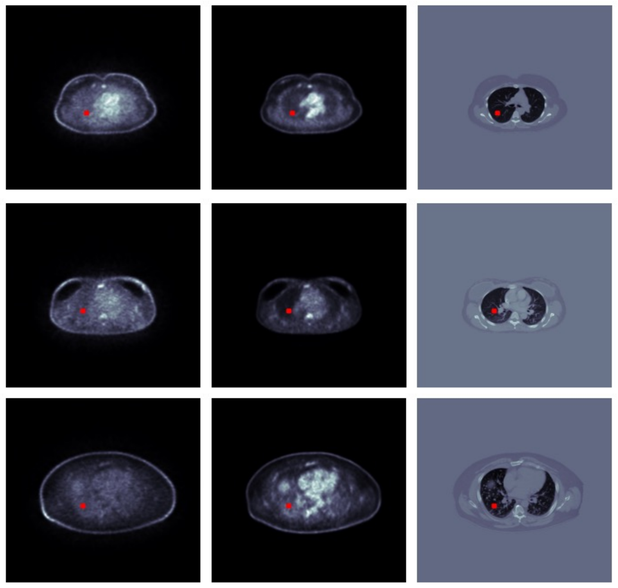

Fig. 3. Left Column: PET with no Attenuation Correction. Middle Column: PET with Attenuation Correction. Right Column: CT with Attenuation Correction. Line profiles were carefully tested to ensure it will pass through the posterior left lung in the thoracic slices. Plotted in red are the line profiles as they pass through lung PET and CT scans of three different patients, each with different body sizes.

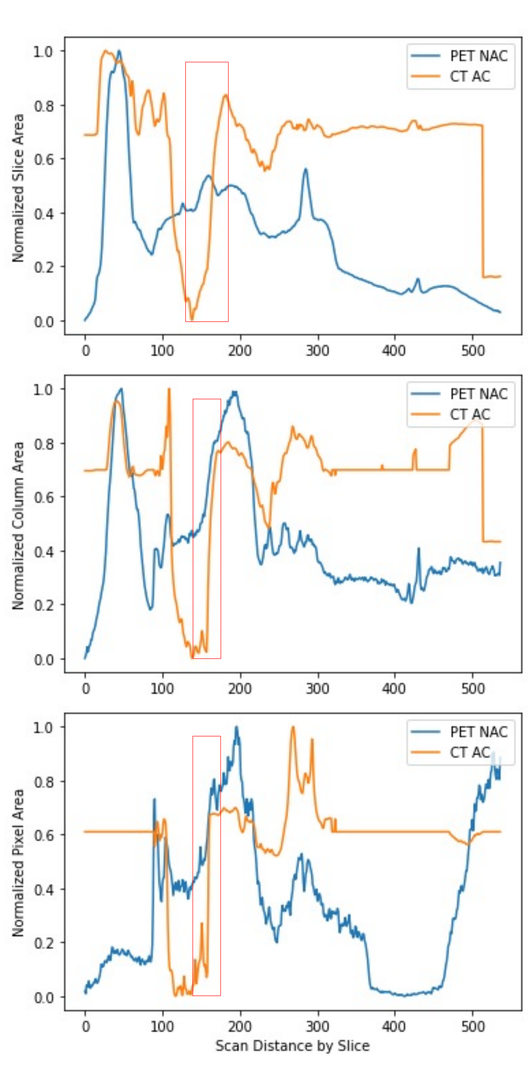

Fig. 4. Comparison of slice, column, and pixel areas per cross-sectional slice to plot the whole-body profile of a sample patient's PET/CT scan. The three graphs exhibited severe, mild, and no misregistration (top to bottom).

Conclusion

- An automatic computer-assisted model was successfully developed to detect the edge of the lower lung in whole-body PET and CT scans.
- Implementing the model in GE PET/CT scanners and eventually Siemens scanners will allow for a real-time misregistration alert system, reducing the number of repeat scans, patient wait times, and accelerating the potential for accurate reading and pinpointing of tumors for treatment and therapy.

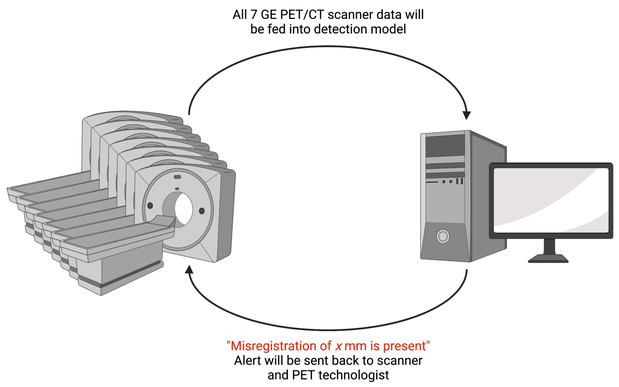

Fig. 5. Future implementation scheme of the detection model, feeding data from all GE PET/CT scanners at MD Anderson.

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