Validation of a Scatter Correction Method for Total-Body Positron Emission Tomography

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Introduction

Total-Body Positron Emission Tomography (TB-PET)

- uEXPLORER is a total-body PET/CT scanner with 194 cm axial field of view (FOV)
- Provides substantially improved image quality for PET imaging* [1]
- Spatial resolution of about 3.0 mm
- 15-68-fold increase in sensitivity* [2]

* compared to conventional PET scanners with shorter axial FOV

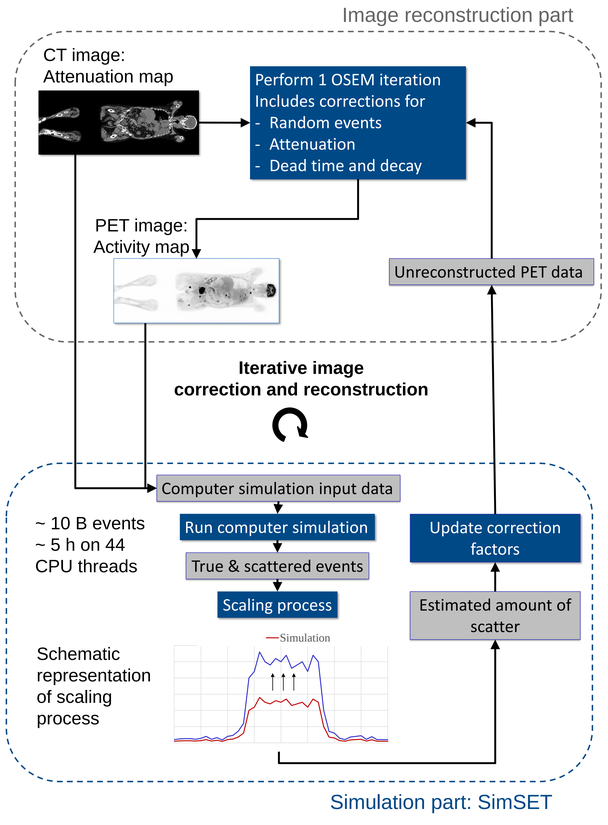
Figure 1
uEXPLORER installed at the EXPLORER molecular imaging center (EMIC) in Sacramento. This is the first clinically operating total-body PET scanner in the US.
It has close to 100 B lines of response, which makes data corrections computationally expensive.

Data corrections in Total-Body PET

- Scattered events degrade contrast and quantitative accuracy [3]; correction for scattered photons always needed for human PET imaging
- Large number of detectors and widened acceptance angles in TB-PET
  → dramatic increase in dataset sizes
  → increased demands on image reconstruction and scatter correction (SC)
- This work: SC method based on computer simulations; implemented in the UC Davis in-house reconstruction framework
- Validation using phantom and human subject data

Scatter Correction Framework

- Iterative image reconstruction (OSEM)



Validation

Quantitative Image Quality Assessment Using the NEMA IQ phantom

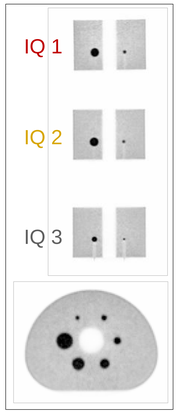
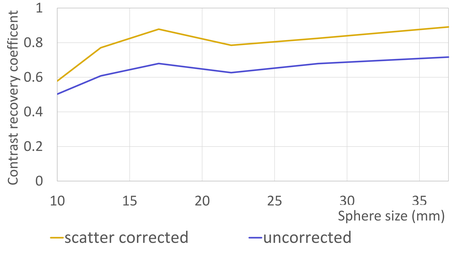


Figure 2 (left)
Reconstructed images of 3 standard test phantoms at different axial positions. Coronal (top) and transverse view (bottom).
- Six spheres of different diameters between 10 mm and 37 mm
- Activity ratio of hot spheres to background: 4:1
- Reconstruction parameters:
  4 OSEM iterations and 3 SC iterations

Figure 3 (below)
The contrast recovery coefficient (CRC) was quantified for all 6 sphere sizes. Only the phantom placed in the axial center of the scanner was evaluated in this study.
Results:
- Contrast recovery of up to 90% was achieved with SC
- For comparison: without SC, CRC was < 75%



Qualitative Image Quality Assessment in Human Subjects

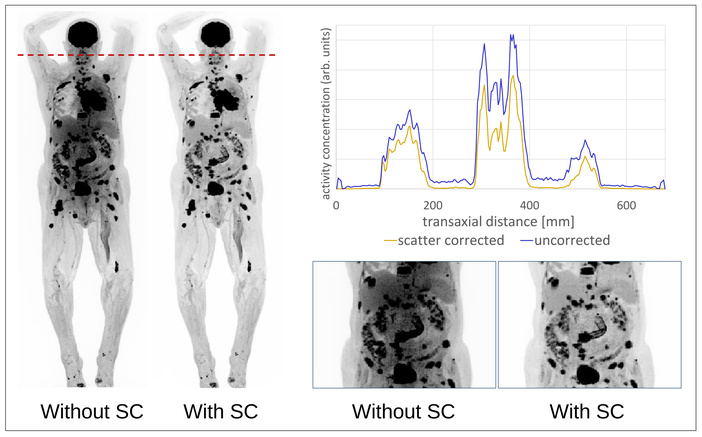


Figure 4
Left: Maximum intensity projections (MIPs) of a human subject without and with scatter correction
- 83 y/o patient with metastatic lung cancer
- 10 mCi [^{18}F]FDG
- Scanned for 20 min @ 2 h post injection

Top, right: line profile through head and neck region. Scattered events in the region between arms and head have been corrected successfully.

Bottom right: zoomed in on abdominal region. The scatter corrected image shows vastly improved lesion conspicuity and increased contrast.

Quantitative Image Quality Assessment in Human Subjects

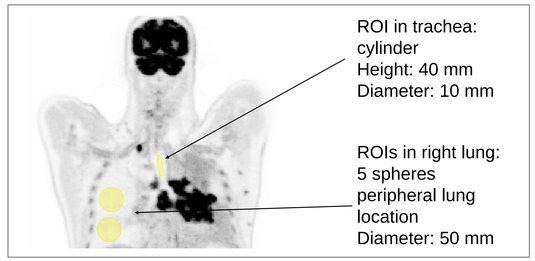


Figure 5
Scatter clearance in trachea.
ROIs were placed in lung tissue and trachea and the average activity concentration was determined.
Results:
- Trachea should have no activity
- With SC: 31.0% less activity concentration in trachea compared to lung tissue
- Residual scatter can be attributed to motion

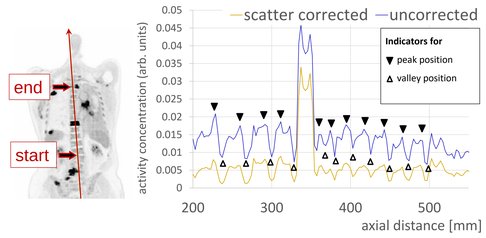


Figure 6
Peak to valley ratio (PVR) in a line profile through the spine.
Average of 11 PVRs was calculated with and without SC.
Results:
- With SC: PVR = 3.46
- Without SC: PVR = 1.98

Conclusions & Outlook

- Successful implementation of SC framework with quantitative and qualitative validation
- Higher lesion conspicuity, improved contrast and improved image quality compared to uncorrected images
- Serves as ground truth for optimizing performance of future SC methods
- Next steps: optimizing computational efficiency and improving quantitative accuracy

References

[1] Badawi et al., 10.2967/jnumed.119.226498
[2] Spencer et al., 10.2967/jnumed.120.250597
[3] Zaidi et al., 10.1016/j.cpet.2007.10.003

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