Small animal imaging with Human PET

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INTRODUCTION & METHODS

Positron Emission Tomography (PET) imaging studies in rodents provide valuable information in the assessment of animal models for human diseases. Current microPET systems offer the high resolution needed to explore small organs but suffer from a reduced axial field-of view (FOV) which usually covers only a limited part of the animal body. Multiple bed positions are then used to obtain whole scans resulting in increased scan time and incomplete dynamic data. In contrast, human PET systems have larger axial FOV but a lower resolution. In this study, an image-based model of the scanner spatial response function in combination with a 3D-OSEM reconstruction algorithm were used to improve reconstructed spatial resolution of the Siemens ECAT EXACT HR+ PET scanner. The final aim was to allow whole body dynamic scanning of small rodents with sufficient resolution and without moving the scanner bed.

1. An 18F pseudo-point source was acquired at different radial and axial locations within the scanner FOV.
   - Data reconstructed with 3D-OSEM without resolution modeling (voxel size: 0.5 x 0.5 x 2.42 mm).
   - For each reconstructed point source position, radial, tangential and axial 1D profiles were extracted and fitted with analytical double Gaussian functions.
   - A resolution model was derived from the properties of the Gaussian fitting (standard deviations: σ_1, σ_2 and the ratio of the weights between the first and the second Gaussians: ρ). This model was used in a 3D-OSEM reconstruction (3D-OSEM-RM) [1].
2. Both the NEMA NU 2-1994 performance phantoms and the NEMA NU4-2008 image quality phantom were used to evaluate the overall image quality.
3. Static and dynamic scans on the HR+ were obtained for FDG and NaF in rats in order to assess the improvements afforded by 3D-OSEM-RM.

HIGHLIGHTS

NaF images obtained with HR+ and reconstructed with the in-built 2D-FBP (a), the 3D-OSEM-RM (b) and acquired with a Focus 120 microPET reconstructed with the 3D MAP (c).

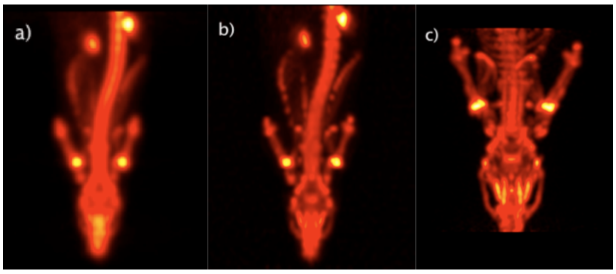

Figure 1: NaF rat images, a) obtained with HR+ and the native 2D-FBP reconstruction; b) obtained with HR+ and reconstructed with 3D-OSEM-RM and c) obtained with a Focus 120 microPET and reconstructed with 3D maximum a posteriori algorithm.

RESULTS & DISCUSSION

Figure 2 shows the radial profiles of the point source at different radial positions within the scanner FOV. An Image of the point source reconstructed with 3D-OSEM is also shown.

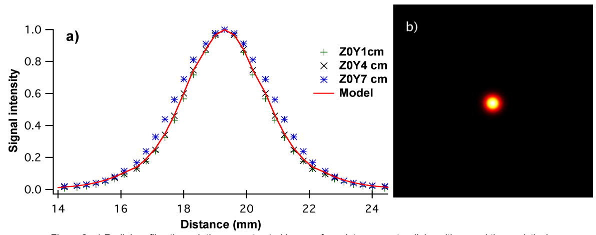

Figure 2: a) Radial profiles through the reconstructed image of a point source at radial positions and the analytical two Gaussian functions (red); b) point source image (Z=0, Y=4 cm) reconstructed with 3D-OSEM

The standard deviations of the two Gaussians used to model the transaxial, (axial) resolution in a central FOV of 5 cm radius were σ_1 = 1.6 (2.75) mm and σ_2 = 3.66 (4.16) mm. Image uniformity and accuracy of scatter and attenuation corrections, evaluated following NEMA NU 2-1994, were found to be very similar between 3D-OSEM, 3D-OSEM-RM, 2D- and 3D-FBP reconstructed images.

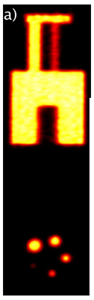

Table 1: standard deviation in percent (%std) of the recovery coefficients

	1 mm	2 mm	3 mm	4 mm	5 mm
HR+: 3D-OSEM	15.64	7.29	2.79	2.73	1.32
HR+: 3D-OSEM-RM	18.81	9.09	5.21	2.71	1.45
Focus 120: FBP	11.38	5.66	3.52	4.21	3.96

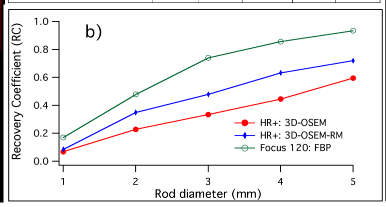

Figure 3: a) and c) transverse and sagital views of the IQ phantom as scanned with the Focus 120 and HR+, respectively; b) Recovery coefficients of the hot rods.

When using the NEMA NU4-2008 image quality phantom a significant increase of the hot rod recovery coefficient was observed with 3D-OSEM_RM reconstruction compared to 3D-OSEM. This effect was rod size dependent and amounted to 17-35% for 3D-OSEM-RM compared to 3D-OSEM and to 35-62% compared to FBP reconstructions. Nevertheless the values obtained with 3D-OSEM-RM were around 20-35% lower than those obtained with a FOCUS 120 microPET scanner.

Most of the small brain structures observed on microPET images were also visible on the images obtained with HR+ and 3D-OSEM-RM. Rat cerebral Mrglu values calculated on the HR+ 3D-OSEM-RM images were in the range of published values [2] (e.g. whole brain = 25.34, hypothalamus = 27.90 µmol/min/100g). Input function was derived from the image.

SUMMARY

Using an approximate model of the ECAT EXACT HR+ spatial response in 3D-OSEM resulted in sufficient image quality for **dynamic whole body scans of small rodents**, despite the large scanner bore, and **resulted in improved contrast** compared to images generated using the built-in software. These results show **the benefit of a large axial FOV and open the door for simultaneous scanning of multiple rats**. It is planned to apply this methodology to small animal dosimetry and modeling studies in our laboratory.

REFERENCES

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imagination at work