MSc PROJECT

KING'S College LONDON

Potential image quality improvements in Single Photon Emission Computed Tomography (SPECT) by use of advanced statistical image reconstruction algorithms

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Master of Science in Medical Engineering and Physics

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Integration of advanced 3D SPECT modeling into the open-source STIR framework

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Purpose: The Software for Tomographic Image Reconstruction (STIR, http://stir.sourceforge.net) package is an open source object-oriented library implemented in C++. Although its modular design is suitable for reconstructing data from several modalities, it currently only supports Positron Emission tomography (PET) data. In this work, the authors present results for single photon emission Computed Tomography (SPECT) imaging.

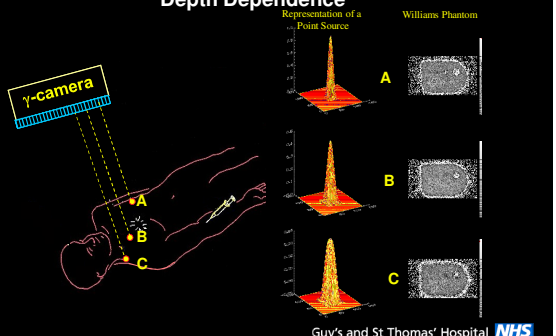
Methods: This was achieved by the complete integration of a 3D SPECT system matrix modeling library into STIR.

Results: The authors demonstrate the flexibility of the combined software by reconstructing simulated and acquired projections from three different scanners with different iterative algorithms of STIR.

Conclusions: The extension of the open source STIR project with advanced SPECT modeling will enable the research community to study the performance of several algorithms on SPECT data, and potentially implement new algorithms by extending the existing framework. © 2013 American Association of Physicists in Medicine. [http://dx.doi.org/10.1118/1.4816676]

Gamma camera imaging

Depth Dependence



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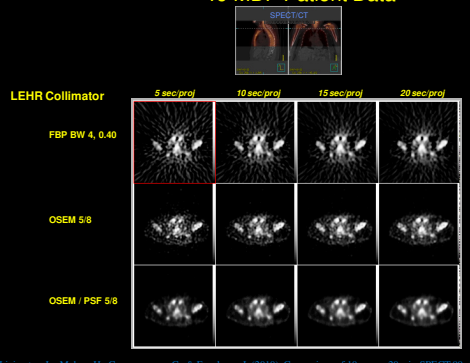
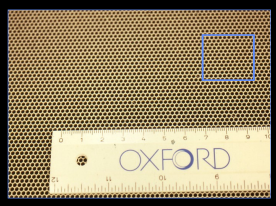
PSF IR SPECT

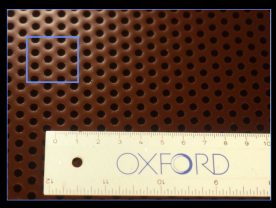
^{99m}Tc-MDP Patient Data



Livieratos, L., Mohan, H., Gnanasegaran, G., & Fogelman, I. (2010). Comparison of 10 versus 20 min SPECT 99mTc-MDP bone scans: use of 3D-OSEM image reconstruction with distance-dependent resolution modelling. *Nuclear medicine communications*, *31*(12), 1045-1053.

Parallel Hole Collimators





$$FWHM_c = d\frac{(L_e+b)}{L_e}$$

d: diameter of the collimator hole
b: distance from collimator face
Le:effective length of collimator hole

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PROJECT AIM

Evaluate the performance of **OSEM**, **OSMAPOSL** and **OSSPS** ordered-subsets reconstruction algorithms available in **STIR** - "**Software for Tomographic Image Reconstruction**"

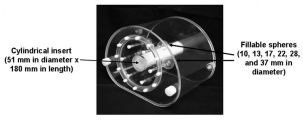
CONDITIONS

- Distance-dependant resolution modelling
- Collimator design (LEGP, LEHR,MEGP) – **Point source data, Siemens Symbia**
- Scatter time (10 s/projection, 20 s/projection) – **IEC phantom, Philips Precedence**
- Scatter kernel – **IEC phantom , Philips Precedence**

MEASURED PARAMETERS

- Spatial resolution - FWHM over iterations
- Convergence over iterations
- Noise – COV over iterations
- SNR over iterations

IEC phantom



MATERIALS & METHODS - PSF modelling

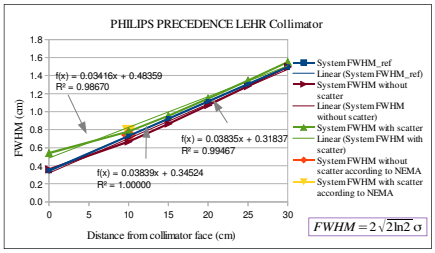
PSF type of correction {2D // 3D //Geometrical}
psf type:= 2D

$$FWHM_s = \sqrt{FWHM_i^2 + FWHM_c^2 + FWHM_{sk}^2}$$

$$FWHM_c = d\frac{(L_e+b)}{L_e}$$

d: diameter of the collimator hole
b: distance from collimator face
Le:effective length of collimator hole

Next 2 parameters define the PSF
collimator slope := 0.0163
collimator sigma 0(cm) := 0.1466



$$FWHM = 2\sqrt{2\ln 2}\,\sigma$$

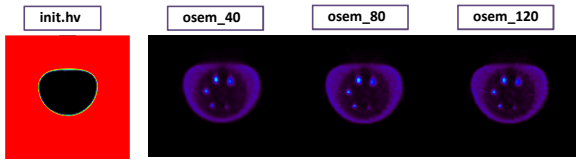
MATERIALS & METHODS - Reconstruction set-up

OSSPS Parameters := // OSMAPOSL Parameters

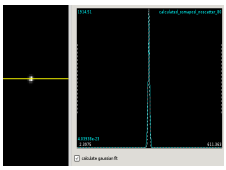
prior type := quadratic // FilterRootPrior
Quadratic Prior Parameters:=
penalisation factor := 0.04 // 1.0 // 0
number of subsets:= 8
number of subiterations:= 128
Save estimates at subiteration intervals:= 8

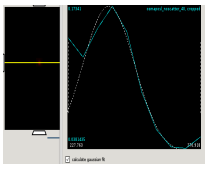
initial estimate:= osem_80 // init.hv

specify relaxation scheme
lambda = relaxation_parameter/ (1+relaxation_gamma*(subiteration_num/ num_subsets)
relaxation parameter := 1
relaxation gamma:= 0.1

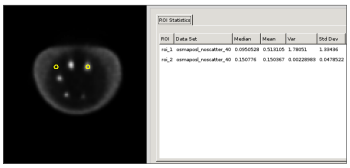


MATERIALS & METHODS - Analysis of the results





FWHM

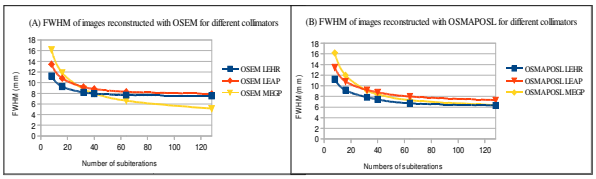


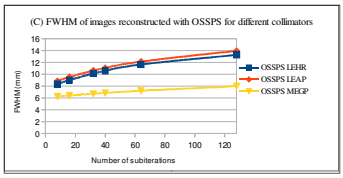
$$ROI\ Counts\ Ratio = \frac{Mean\ counts\ hot\ ROI}{Mean\ counts\ background\ ROI}$$

$$COV = \frac{standard\ deviation_{big\ sphere}}{ROI\ mean\ counts_{big\ sphere}}$$

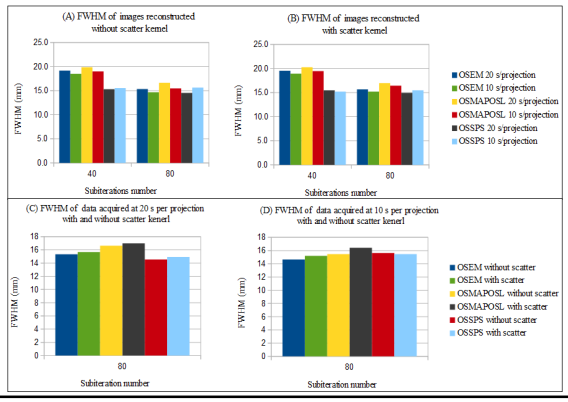
$$SNR = \frac{ROI\ mean\ counts_{big\ sphere}}{standard\ deviation_{background\ ROI}}$$

RESULTS - Point source data_2D PSF correction

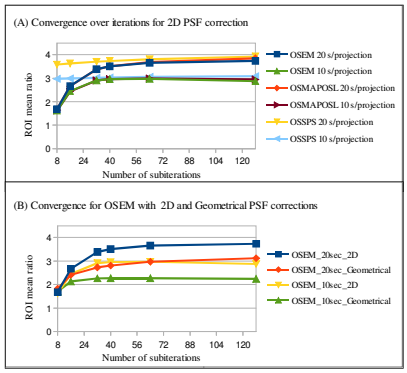




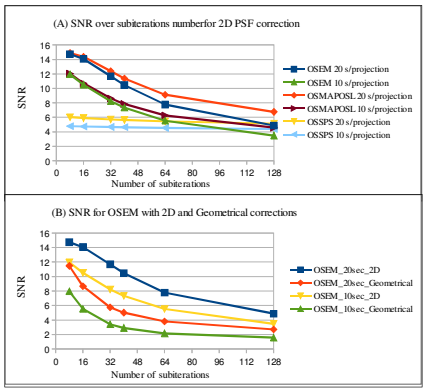
RESULTS - IEC phantom data_2D PSF correction



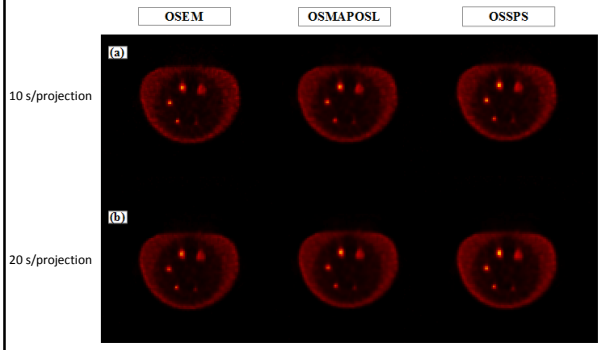
RESULTS - Convergence over iterations



RESULTS - SNR

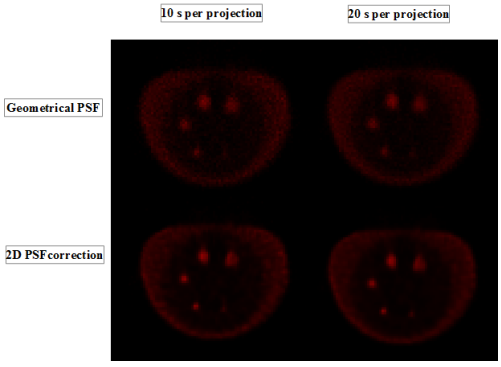


RESULTS - SNR



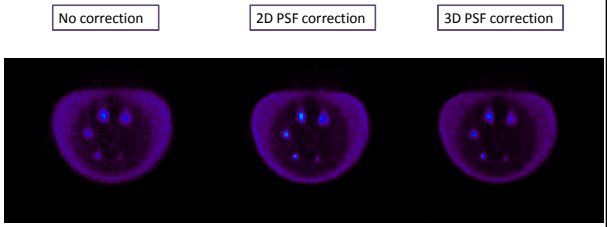
8 subsets and 128 subiterations

RESULTS - SNR_OSEM



8 subsets and 128 subiterations

RESULTS - OSEM_Geometrical,2D and 3D PSF correction



OSEM (8 subsets, 128 subiterations)

CONCLUSION

- Although resolution recovery requires longer calculation time when compared to reconstruction without **PSF correction**, it allows to obtain improved image quality;
- **OSSPS** requires further investigation to understand current implementation;
- In terms of image resolution, the best recovery is achieved for data acquired with **MEGP** collimator;
- In terms of SNR, using **short scan time and resolution** recovery seems to offer a good compromise;
- Further image quality improvement seem to be obtained with **3D PSF modelling** at the cost of a longer computational time.

It is possible to start obtaining results with SPECT STIR reconstruction within 10 weeks

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