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Quantitative study of clinical SPECT : image reconstruction and sensitivity

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Introduction

- Single Photon Computed Tomography gamma camera is a useful device in nuclear medicine,
- Quality controls and evaluations are required to maintain good performance.

Aim

- Evaluate quantitative characteristics:
  - Sensitivity variation with the source-detector distance,
  - Image reconstruction, by investigating the tomographic non-uniformity and contrast

Materials and methods

Experimental set-up

- Double headed Symbia T6 SPECT/CT, Siemens (table 1) [1],
- ^{99m}Tc radioisotope, 15 % energy window centered at 140 keV gamma peak

Sensitivity in air

- 1 ml syringe filled with 44.59 MBq of ^{99m}Tc,
- 2 minutes acquisition, at different source-detector distances: 10 (constructor reference), 20, 30, 40, 50 and 60 cm,
- Sensitivity calculated as : $Sensitivity\,(cpm/\mu Ci) = \frac{counts\,/\,acquisition\ time\,(\min)}{Activity(\mu Ci)}$

Tomographic Sensitivity in air

- Same source as for static sensitivity,
- source-detector distance: 19.5 cm,
- 30 seconds acquisition for 8 projections over 180° per head,
- Acquisition using a 128x128 matrix with a 1.7959 mm pixel size.
- Tomographic sensitivity calculated as the mean of sensitivities calculated for each projection

Image reconstruction

- Jaszczak phantom, filled with water mixed with 485.09 MBq ^{99m}Tc,
- Distance center of the phantom/surface of the collimator: 23 cm ,
- 64 projections over 180° per head, 35 seconds each,
- Images acquisition with a 128x128 matrix and 2.3976 mm pixel size,
- Six spheres of 31.8, 25.4, 19.1, 15.9, 12.7 and 9.5 mm diameters are inserted in the phantom for contrast evaluation,
- A uniform part in the phantom, where no inserts are added, is used to evaluate the tomographic nonuniformity.

Simulation set-up

- GATE (Geant 4 Application for Tomographic Emission) [2], Monte Carlo based platform,
- GATE models: experimental set-up,
- A glass back-compartment used [3], instead of photomultiplier tubes
- Moroccan Grid computing "MaGrid" [4] was used and jobs split to reduce the total simulation time and increase the statistics.

Component	Characteristics
Crystal	59x44.5 cm2, 0.95 cm thickness
Collimator	Holes' diameter: 1.11 mm; Septa thickness: 0.16 mm
PMTs	53 PMTs: 7.6 cm diameter, 6 PMTs: 5.1 cm diameter

Results

Sensitivity in air

185 cpm/µCi at 10 cm , comparable to the constructor recommended value : 202 cpm/µCi

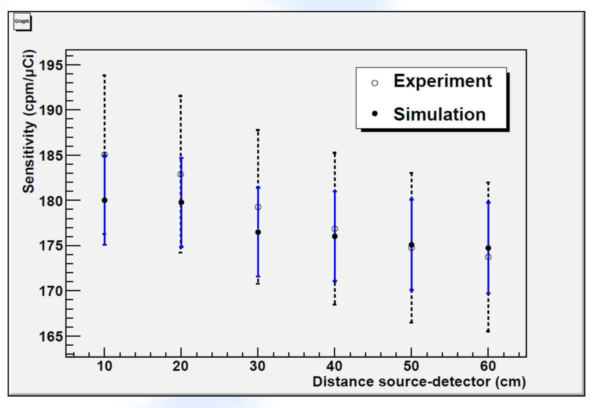

Figure 1: Sensitivity versus source-detector distance

Tomographic sensitivity

- Experimental value for tomographic sensitivity : 168.6 cpm/µCi
- Calculated value using simulation : 150.3 cpm/µCi

Image reconstruction

- Iterative reconstruction method OSEM.
- To enhance experimental image quality :
  Scattering effect corrected by the double window method
  Attenuation correction (CT scanner)

Tomographic non-uniformity: Calculated as: $Non-uniformity = \frac{(\max pixel\ counts)-(\min pixel\ counts)}{(\max pixel\ counts)+(\min pixel\ counts)} \times 100$

- Experimental non-uniformity : with no attenuation correction: 21%, after correcting attenuation: 7.4%,
- Both values within the range (6.92-23.8%) recommended by the American Association of Physicists in Medicine (AAPM) in report N 52 [5]. The uniformity is enhanced when using attenuation correction,
- The simulated non-uniformity value is 53%, due to the lack of sufficient statistics per pixel.

Contrast: $\frac{(Average\ pixel\ cts\ from\ uniform\ section)-(\min pixel\ counts\ per\ cold\ sphere)}{Average\ pixel\ cts\ from\ uniform\ section}$

- Only four cold spheres are visible in the reconstructed images.
- Results got (table 2) are acceptable / AAPM recommendations

(a)
(b)

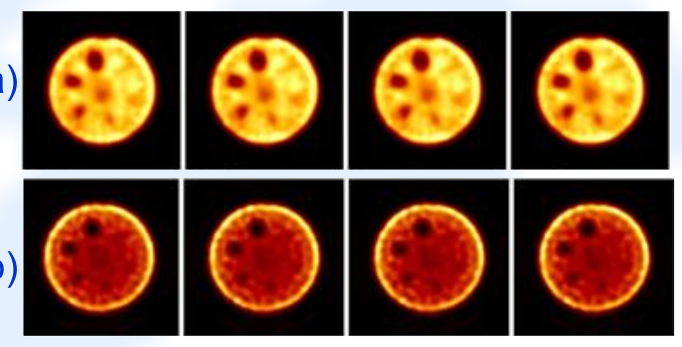

Figure 2: Image reconstruction at spheres part, including scatter correction, for experiment with (a) and without (b) attenuation correction

Table2 : contrast values for different visual spheres diameters for reconstruction considering scatter correction

Spheres' diameters	31.8 mm	25.4 mm	19.1 mm	15.9 mm
AAPM contrast range	0.53-0.73	0.35-0.56	0.21-0.38	0.11-0.27
Measured value of contrast	0.85	0.71	0.42	0.25
Experimental value of contrast with attenuation correction	0.71	0.58	0.42	0.25
Simulated value of contrast	0.68	0.65	0.36	0.22

Conclusion

- A quantitative study was held for a clinical SPECT/CT, experimentally and by simulation,
- Our interest goes here to two quantitative parameters: sensitivity and the image reconstruction,
- The sensitivity value decreases, as expected, versus the source-detector distance,
- The obtained results, concerning contrast and the tomographic non-uniformity, are within the range of report 52 AAPM recommended values,
- Next, we are investigating scatter effect in tomographic acquisitions, to enhance our simulation results.

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References

[1] Siemens Medical, "Symbia True Point SPECT.CT: System Specification", *Siemens Medical Solutions, 2005.*
[2] S. Jan, "GATE: a simulation toolkit for PET and SPECT", *Physics in Medicine and Biology, vol. 49, pp 4543-4561, September 2004.*
[3] K. Assié, I. Gardin, P. Véra and I. Buvat, "Validation of the Monte Carlo simulator GATE for indium 111 imaging", *Physics in Medicine and Biology, vol. 50, pp 3113-3125, June 2005*
[4] C. El Amrani, O. Bouhali and R. Merrouch,"MaGrid: the Moroccan grid computing initiative", *IADIS International Journal on Computer Science and Information Systems*, Vol. 4, No. 1, pp. 85-92, February 2009.
[5] AAPM, "Quantization of SPECT performances", report N° 52, April 1995.