The Influence of Noise in Dynamic PET Direct Reconstruction

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***Abstract*—In this paper the efficiency of dynamic PET direct reconstruction algorithm on noisy data has been studied. Simulation has been performed in order to extract indexes that quantitatively describe the goodness of kinetic parameters estimation and dynamic images reconstruction.**

I. INTRODUCTION

Positron emission tomography (PET) dynamic studies are performed to quantify tissue-specific biochemical properties. In routine use PET scanners, acquired data are subject to several noise sources, such as accidental scattering, random scattering and attenuation, intrinsic thermal and electronic noise [1]; they can compromise accuracy in determining the tracer behavior if not suitably corrected or accounted for. In conventional reconstruction and analysis methods the sequence of emission images is first reconstructed and then, in a separate step, the estimation of kinetic parameters from time activity curves (TACs) is performed. Kinetic analysis in a voxel-by-voxel fashion provides parametric images that can be used to determine the spatial distribution of the behavior of specific tracer [2]. Recently, direct reconstruction methods are proposed, that combine emission image reconstruction and kinetic modeling into a single formula and estimate parametric images directly from raw projection data [3]. No studies are performed since now about the evaluation of the performance of the direct reconstruction algorithm when noisy data are considered. In the present work we study the behavior of the direct reconstruction algorithm, starting from dynamic PET data with different noise degrees.

II. SIMULATION

Sinograms data were generated by projection of a uniformly emitting (according to Poisson statistics) cylindrical phantom with radius of 10 cm and length of 15 cm, in a circular FOV of 70 cm in diameter. Dynamic emission data were generated changing the emission mean value inside the cylinder frame-by-frame, according to the two-tissue, 4-k parameter kinetic model [4]. The k-values used as input to the simulation were relevant to 18F-FDG tracer in different tissues: normal tissue, and excessive tracer accumulating tissue (pathological). Emission time frame duration varied according to typical values used in clinical PET data acquisitions. On each projected dynamic data set, combinations of random (RS), accidental events (AC) and measurement noise (GN) were added to obtain the total sinogram, noisy values varied from 0% to 30% of the maximum sinogram value. Simulation has been repeated 50 times, for each noisy condition. Direct reconstruction was performed according to the OTEM algorithm [3].

The normalized percentage error was used for quantitatively evaluating the goodness of the kinetic parameters and reconstructed images estimations.

III. RESULTS

Representative resulting errors relevant to kinetic parameters estimation for different noisy conditions are shown in table 1; f_v is the fractional volume of blood in the tissue. The GN value was equal to 2%.

TABLE I. PERCENTAGE ERRORS OF ESTIMATED KINETIC PARAMETERS

AC (%)	RS (%)	K1 %	K2 %	K3 %	K4 %	fv
0	0	0.049±0.030	0.107±0.047	1.942±0.606	1.282±1.598	-0.073±0.165
0	30	0.181±0.128	0.366±0.189	5.064±1.451	5.432±3.724	-0.872±0.697
30	0	0.258±0.083	0.499±0.128	6.628±1.308	6.560±3.130	-1.475±0.509
30	30	0.210±0.106	0.416±0.153	5.537±1.479	4.847±4.029	-1.880±0.652

As far as the percentage errors on reconstructed images, as expected, the error is higher in low emission images for any noise percentage values; moreover, the error values increase for increasing levels of noise. However, in any case, the percentage error is always less than 1%.

IV. CONCLUSIONS

The behavior of dynamic PET direct reconstruction algorithm on noisy data has been studied. Simulation has been performed in order to extract indexes that quantitatively describe the goodness of kinetic parameters estimation and dynamic images reconstruction. Direct reconstruction algorithm has a good performance also in presence of noise.

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