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Study on basis function methods reliance on θ_3 parameter limits – phantom study

Test problem

After simulation studies described in appendix a θ_3-effect was studied also with phantom data. This Montreal phantom was given from the Tampere university of technology [Wallius et al. 2003] and it is based on [^{18}F]L165 study. In Image 1. you can see the phantom with regions representing caudate (up in the middle), putamen (up in the right) and cerebellum (down in the middle). The noise model consists of Gaussian part and Poisson part and the variance of the Gaussian noise is varied to be 25, 75 or 125.

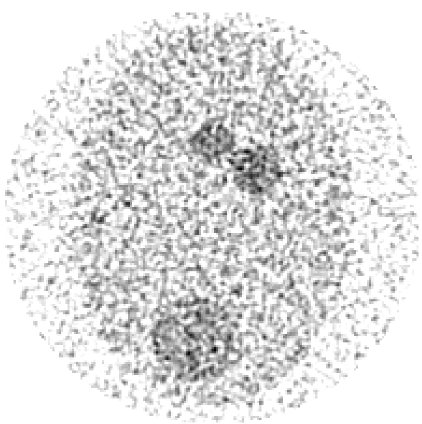

Image 1. Frame 10 from the Montreal phantom with Poisson and Gaussian (variance 75) noise.

The lower limit θ_{3min} was varied from value 0.007 to 0.05. The value of θ_{3min} always has to be greater than the decay constant λ plus $\frac{k_2^{min}}{1+BP^{max}}$. Since the quotient part is very small compared to decay constant, which is 0.0063 min^{-1} for F^{18}, it would have been enough to keep θ_{3min} greater than 0.0064. Maximum value was kept to be 0.6 because the lower limit alteration was already found to have the most effect on BP estimates with simulation study.

Test results

With specified θ_{3min} values the percentage of pixels where the BF method ran into θ_3 limits varied only from 26% to 31 % for the whole image, which is much less than what was recorded in appendix a. This might be due to the fact that simulated data in appendix a did not contain background. The variation inside ROIs is not known.

Montreal phantom was created with BP values 1,2588 and 1,2930 in caudate and putamen. In Table 1 we can see that θ_{3min} = 0,02 induces the best estimates for BP values regardless of the noise variance.

Table 1. BP values with different noise variance and different θ_3 minimum.

variance of Gaussian noise		25			75			125	
basis function method		caudate	putamen		caudate	putamen		caudate	putamen
Theta3 minimum									
0.007		2.531	2.535		3.287	4.590		2.700	5.381
0.0085		1.884	1.812		2.019	2.417		1.795	2.487
0.01		1.695	1.646		1.703	1.905		1.606	1.944
0.012		1.514	1.520		1.496	1.620		1.482	1.633
0.015		1.362	1.411		1.325	1.419		1.344	1.419
0.02		1.225	1.286		1.184	1.239		1.201	1.272
0.03		1.062	1.111		1.019	1.055		1.032	1.105
0.04		0.956	1.000		0.922	0.947		0.930	0.998
0.05		0.885	0.924		0.859	0.877		0.864	0.937
srtm		0.924	0.924		0.893	0.876		0.829	0.962
Logan		0.961	0.967		0.970	1.004		0.920	1.126

Same effects were seen now as was in appendix a: smaller lower limits caused long tail to the right end of BP distribution while bigger lower limits enforced mean value of the distribution towards left. It is evident that basis function method is very dependent on lower limit of θ_3, but compared to graphical analysis and simplified reference tissue model (table 1) the results are still tolerable.

References

1. Wallius E and Ruotsalainen U: A method for assessing methodological and biological variation in receptor occupancy studies with PET. 1st Nordic Workshop on Brain Imaging and Neuroinformatics, 2003.