Simultaneous Dual-Isotopes PET Imaging Using Triple Coincidence and Artificial Neural Network

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INTRODUCTION

Positron emission tomography (PET) is widely recognized as a highly effective functional imaging modality. Unfortunately, however, because signals used for image reconstruction by PET for both isotopes are from the 511 keV annihilation photons, it is difficult to separate signals from the two isotopes [1]. Methods that have been proposed for dual-isotope PET (DIPET) rely on differences in half-lives of the participating [2]. Recently, Andreyev *et al* proposed a novel dual-isotope PET imaging based on the positron-gamma emitters[3]. The method works for dual-isotope with a pair of pure and non-pure isotope; however, it holds some drawbacks: (1) the abundance of recovered coincidence from non-pure isotope is low [4]; (2) The predicted image tends noisy due to the noise propagation from the low counts of recovered coincidence from the non-pure isotope. Therefore, It is worth developing a method to improve the image quality for this DIPET.

AIM

In this work, we proposed a novel separation method for DIPET based on the triple coincidence and artificial neural network. The introduction of the artificial neural networks into DIPET can effectively separate the signal of dual-isotope, yielding a better signal-to-noise ratio.

METHODS

The DIPET method is based on the use of a combination of a pure and a nonpure positron emitter for dual isotopes PET proposed by the University of British Columbia (UBC). We improved this method by introducing an artificial neural network for further enhancing the image quality. To validate the proposed method, simulations of a three-rod phantom (filled in F-18 and I-124) is performed using GATE/MPHG software [5].

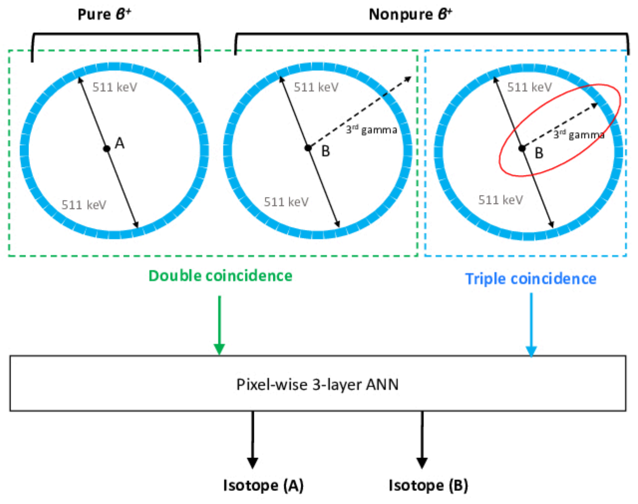

Figure 1 The overall framework of ANN-based dual Isotope PET imaging

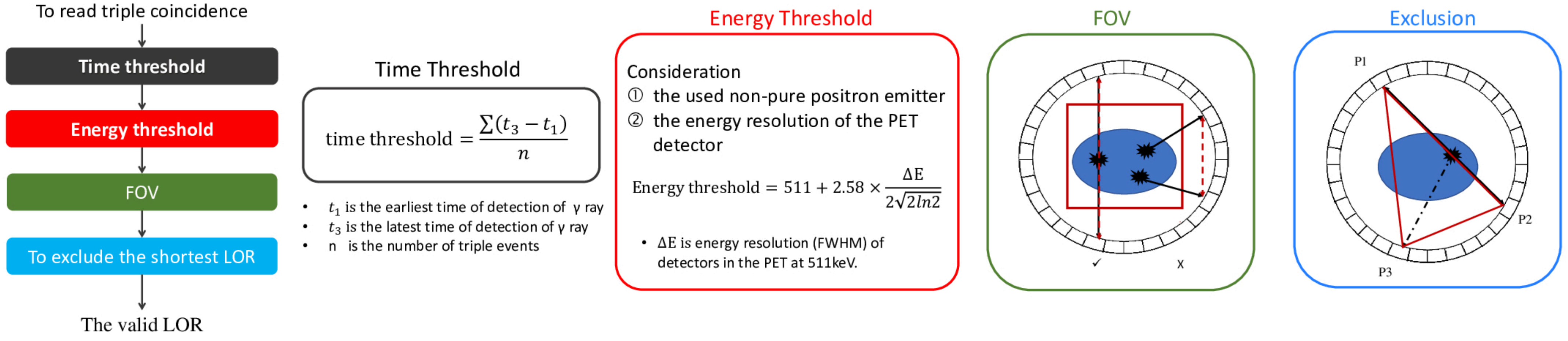

Figure 2. The recovery procedure of triple coincidence for dual isotope PET imaging

RESULTS

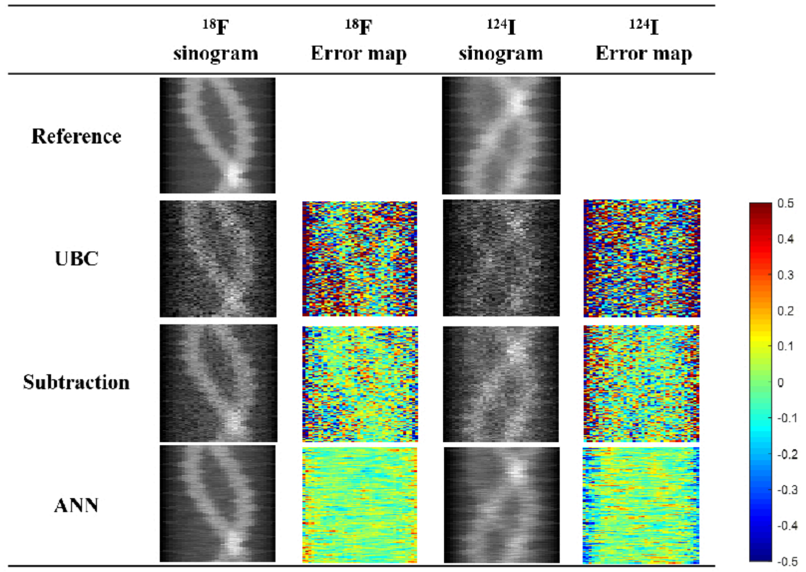

Figure 3. Comparison of UBC and ANN-based predicted sinogram for dual isotope separation

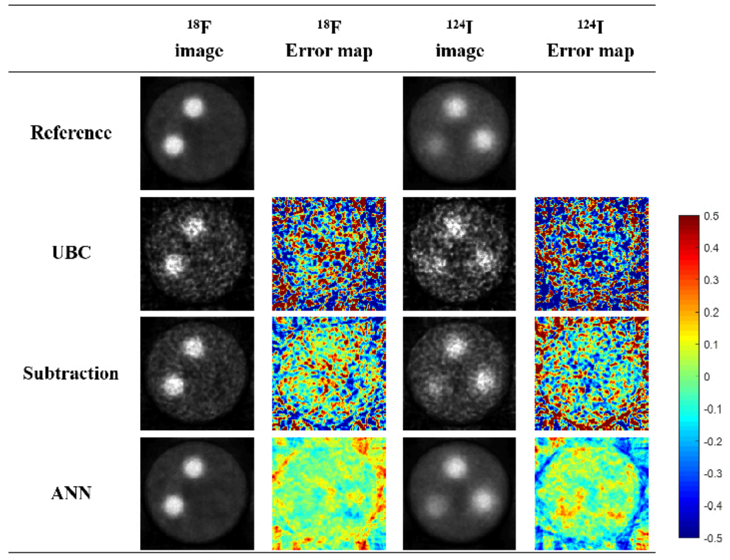

Figure 4. Comparison of UBC and ANN-based reconstructed images for dual isotope separation

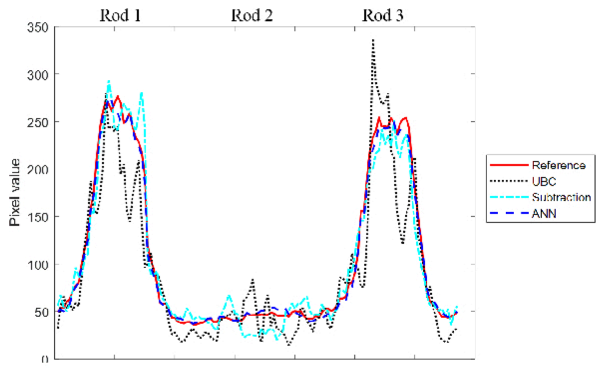

Figure 5. Comparison of image profiles from F-18 reconstructed images

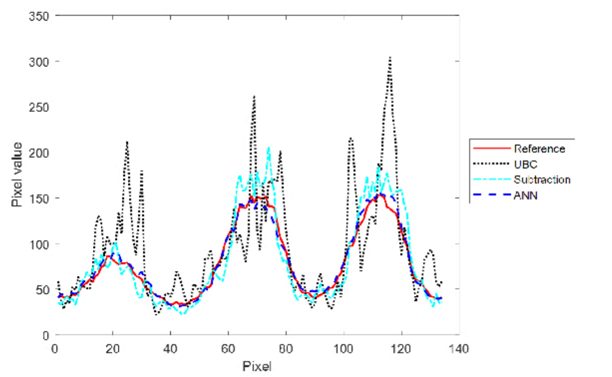

Figure 6. Comparison of image profiles from I-124 reconstructed images

Table 1. Comparison of relative bias of F-18 reconstructed images

^{18}F	Relative bias(%)				NRMSE
	Rod 1	Rod 2	Rod 3	Background	
UBC	-9.3	-1.4	-11.7	7.1	0.3145
Subtraction	-6.3	-24.9	-7.1	0.4	0.1668
ANN	-3.0	4.2	-2.1	0.6	0.0593

Table 2. Comparison of relative bias of I-124 reconstructed images

^{124}I	Relative bias(%)				NRMSE
	Rod 1	Rod 2	Rod 3	Background	
UBC	33.1	-0.8	20.9	-12.8	0.4599
Subtraction	18.8	8.8	13.8	1.2	0.2470
ANN	8.6	-1.7	4.7	-0.3	0.0871

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CONCLUSIONS

Monte Carlo simulation is a very powerful tool to generate the database for ANN training since the ground-truth data for the dual isotope data is known. Our proposed method could get a higher recovering rate of non-pure emitters while retaining similar quantitative recovery with the single-isotope image. Moreover, the method can be applied to other pure emitters and non-pure emitters. Further work is needed to apply the technique on a mouse whole body (MOBY) phantom to verify the feasibility of the proposed method.

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