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Assessment of the wavelet transform in reduction of noise from the simulated PET images

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Introduction: Positron Emission Tomography (PET) is a technique to acquire the three dimensional distribution of the radiotracers in the patients' body. PET has a very good sensitivity and specificity in diagnosis and differentiation of the malignant from the benign tumors. Nuclear medicine has always been suffered from the poor count density of its images. Though the signal-to-noise ratio is considerably higher in PET than the single photon emission tomography (SPET), it is yet much lower than the other tomography techniques such as the computed tomography (CT).

The noise removal in nuclear medicine is traditionally based on the Fourier decomposition of the images. This method is exclusively upon the frequency components; irrespective to the location of the noise or signal. The wavelet transform presented a solution since it provides information on frequency while retaining information on time. This has overcome the shortcoming of Fourier transform and it has been used for signal processing, such as noise reduction, edge detection, compression, etc.

Materials & Methods: In this research, the NURBS-based Cardiac-Torso (NCAT) phantom was used to generate the torso of a typical human as the virtual object to be imaged. The activity distribution in the phantom was adjusted based on the ^{18}F-FDG uptakes of the organs in a normal human. The SimSET PET simulator, version 2.6.2.6 was used to image the torso phantoms. The images were acquired using 250 million and for reference image we acquired an image with high counts (6 milliards). Then we tried to de-noise the noisy image by different four methods of wavelet de-noising: a) Single-level discrete wavelet transform or DWT, b) Single-level discrete stationary wavelet transform or SWT, c) Global thresholding and d) Level dependent thresholding. All the calculation was performed as a piece of software developed in

MATLAB 7.1.

Results & discussion: According to the results, all of these methods are effective for de-noising but their results are different. In DWT and SWT, the test images were decomposed into the approximation, horizontal, vertical and diagonal details. Then images were reconstructed again using the different combinations of the approximation and details. In nuclear medicine images high frequency noise exists; and when we eliminate details that they contain high- frequency information, noise reduce is significantly. Therefore, the best result in SWT and DWT is relative to “only approximation” reconstruction procedure.

Our results indicate Global (uniform) thresholding is more successful than Level dependent thresholding in de-noising. We presume between all methods that we examined on simulated PET images, SWT using “only approximation” procedure and Global thresholding have best result in de-noising. Using these methods noise reduction is more than 80% (according to calculation of percentage of RMSE decrease).

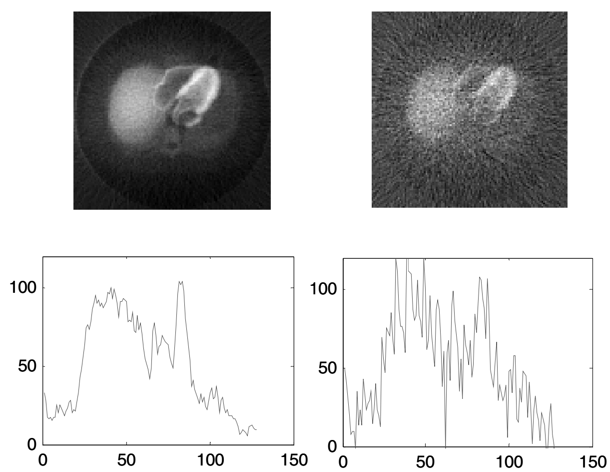

Figure 1- First row, from left to right: reference image and corresponding noisy image. Second row: line profiles of the images in the first row

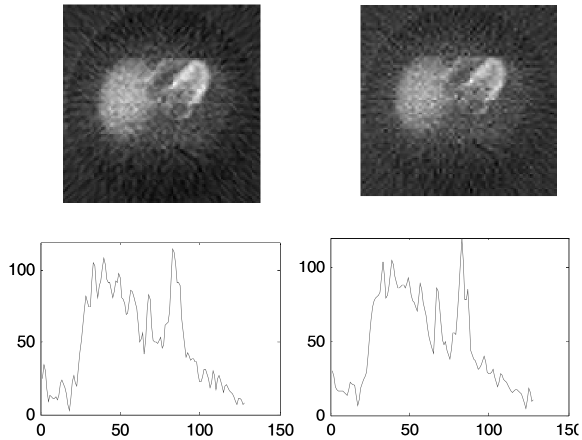

Figure 2- First row, from left to right: the same test image (noisy image) de-noised using SWT and de-noised using Global thresholding. Second row: line profiles of the images in the first row

On the other part, noise reduction using wavelet transform and losing of high frequency information are simultaneous with each other. It seems we should attend to mutual agreement between noise reduction and visual quality of the image.

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