Phantom measurements

The Jaszczak SPECT Phantom was used for image quality assessment. The phantom is cylindrical and includes six hollow spheres, with inner diameters of 10, 12, 16, 20, 25, and 31 mm, respectively. The phantom and the spheres were filled with an aqueous solution containing ^{177}Lu-DOTATATE. The ratio between the activity concentration in the spheres and the background compartment of the phantom was approximately 25. In the reconstructed images, the signal-to-noise ratios (SNRs) were calculated as follows:

$$SNR = \frac{N_S - N_B}{\sigma_B} \qquad (1)$$

where N_S is the mean counts in a volume of interest (VOI_S) equal to the inner diameter of the sphere of interest. N_B and σ_B is the mean and standard deviation of the counts in 20 VOIS, equal the size of VOI_S; placed far away from the hot spheres in the Jaszczak phantom. The recovery coefficient was calculated as the measured activity within the sphere in the SPECT image compared to true activity.

Quantitative image quality evaluation of patient images

The image quality of the synthetic intermediate projections (SIPs) and the reconstructed SPECT images for the test set of 15 patients were evaluated by the peak signal-to-noise ratio (PSNR; Eq 1), root mean square error (RMSE; Eq. 2) and structural similarity index metrics (SSIM; Eq 3). These measures are estimate of image quality compared to the reference image. For the SIPs the reference images are the acquired projections. The reference SPECT image is the reconstruction of all 120 acquired projections.

The PSNR is derived from the mean square error and specifies the ratio of the maximal pixel intensity to the power of distortion compare the refence image (RI):

$$\text{PSNR} = 20\, log_{10}\left(\frac{MAX}{RMSE}\right) \quad (1)$$

where MAX is maximum voxel value in the image.

RMSE is square root of the quadratic mean of differences between image (IM) and RI:

$$\text{RMSE} = \sqrt{\frac{1}{\text{nml}}\sum_{x}^{n}\sum_{y}^{m}\sum_{z}^{l}(IM(x,y,z) - RI(x,y,z))^2} \quad (2)$$

n, m and l are the number of voxels in each direction of the SPECT image. $IM(x,y,z)$ and $RI(x,y,z)$ refer to the x, y and z coordinates in the SPECT images. For projection images IM and RI are changed to represent 2D images; $IM(x,y)$ and $RI(x,y)$.

SSIM is a perception-based measure that considers image degradation as perceived change in structural information (*1*). The values of SSIM range from 0 to 1 where a higher value indicates higher similarity between the images. SSIM where calculated by 3×3×3 kernel size as follows:

$$\text{SSIM (IM, RI)} = \frac{(2\mu_{IM}\mu_{RI}+c_1)(2\sigma_{IMRI}+c_2)}{(\mu_{IM}^2+\mu_{RI}^2+c_1)(\sigma_{IM}^2+\sigma_{RI}^2+c_2)} \quad (3)$$

where μ_{IM} is the average of IM, μ_{RI} is the average of RI, σ_{IM}^2 is variance of IM, σ_{RI}^2 is the variance of RI, σ_{IMRI} is covariance of IM and RI. Two variables c_1 and c_2 are used to stabilize the division with a weak denominator defined as:

$$c_1 = (K_1L)^2\ ,\ c_2 = (K_2L)^2$$

where L is the dynamic range of the voxel-values, K_1 and K_2 set by default to 0.01 and 0.03 respectively.

Reference

1. Wang Z, Bovik AC, Sheikh HR, Simoncelli EP. Image quality assessment: from error visibility to structural similarity. *IEEE Trans Image Process.* 2004;13:600-612.