Improvement of Fluorine-18 Planar Images Using Low-Pass Filtering

TO THE EDITOR: The grid pattern caused by collimator spacing and septa thickness can be satisfactorily removed from both planar images and reconstructions with a high cutoff filtering method. This method was extensively used in Leichner et al.'s article (*1*).

By using the two-dimensional Butterworth filter provided by the Odyssey Workbench, a Fourier filtering technique was adapted to analyze the point source images. This technique is similar to image processing techniques that are used to digitally restore classical paintings (*2*). The premise of the method is that Fourier transform analysis can be used to extract, modify or remove specific scene features.

For the ^{18}F point source planar images, the feature that interfered with FWHM analysis was a grid pattern imposed by the large septa of the collimator. The grid pattern also prevented the FWHM and FWTM functions of the Picker Odyssey Workbench from functioning properly. This pattern was a high frequency, two-dimensional spatially periodic pattern that resulted because the septa thickness (3.43 mm) was about the same size as the intrinsic resolution of the crystal/photo multiplier detection system (3–4 mm). In frequency space, the signal power of the grid pattern is concentrated in a small, high frequency region. The spatial frequency of this grid pattern is higher than the geometric resolution of the collimator. The spatial frequency of the grid pattern is approximately the reciprocal of the hole size plus the septal thickness or 0.197 mm^{-1}. The FWHM of the Fourier transform of point response function, which we can assume is Gaussian without the masking effect of the septa, is about 0.44 times the reciprocal of the FWHM in image space. Therefore, the reciprocal is a conservative measure of the frequency space localization or concentration, and represents an area in frequency space containing about 99% of the signal energy. The FWHM at 20 cm is 27 mm and the reciprocal is 0.037 mm^{-1}. At the collimator face, the FWHM is 5.9 mm, with corresponding frequency localization of 0.17 mm^{-1}.

Thus, for the purpose of measuring FWHM and FWTM, the use of a smoothing filter with a high cutoff should introduce practically no error. This hypothesis was verified by the fact that after a certain point (order = 16, cutoff > 0.0435 mm^{-1}), varying the order parameter of the Butterworth filter caused no change in either the FWHM or the FWTM of the point source, but resulted in almost entirely eliminating the grid pattern Thus, the order parameter was set as high as possible to eliminate only the grid pattern from the projection images. For reconstruction, the grid pattern should not and did not cause any artifacts. That is because the spatial frequency of the grid pattern lies beyond the effective cutoff frequency of the filters we used in Leichner et al. (*1*), including the two-dimensional Wiener prefilter used in CHT-protocol reconstructions of Figure 5 in Leichner et al. (*1,3*). The results of the measurements are shown in Table 1. The images were 128 × 128 with a pixel size of 4.67 mm.

TABLE 1
Variation of PSF Parameters with Cutoff of Butterworth Filter Collimator-Source Distance of 20 cm (Order = 16)

Cutoff (mm^{-1})	row FWHM (mm)	col FWHM (mm)	FWTM (mm)
0.0730	26.91	26.11	45.6
0.0684	26.93	26.11	45.8
0.0615	26.93	26.16	46.2
0.0548	26.94	26.24	46.7
0.0445	27.04	26.47	46.7

All cutoffs used resulted in removal of the grid pattern.

REFERENCES

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