A Study of Spatially-Smoothed ITFs

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ABSTRACT: The S/N in images processed with spatially-smoothed ITFs is poorer than that for images processed with the normal ITF. These results suggest that it is not advisable to smooth the ITF in production processing. They also suggest that the geometric correction used in applying the ITF to IUE images is fairly accurate.

The ITFs used in IUE image processing are applied on a pixel-by-pixel basis. Each pixel has its own ITF determined from the individual pixel DNs in the ITF flat-field images. However, a limitation to the data quality is the ability to register the ITF with the spectral image pixels. Any misregistration will appear as a failure to correct for the pixel-to-pixel variations in camera sensitivity. If misregistration is a serious problem, then smoothing the ITF over adjacent pixels could improve the S/N in the processed image.

The current study uses the new LWR ITF2 as a test case; it is presumed that the conclusions would apply to the other cameras as well. Two smoothed ITFs have been produced by inserting an extra step in the creation of the ITF which applies a box filter to the averaged images at each level. This was done using box filters of 2x2 pixels (the "2x2 ITF") and of 3x3 pixels (the "3x3 ITF"). Four images have been processed with each of the three ITFs, the 2x2, the 3x3 and the normal LWR ITF2. Three of these images are current low-dispersion images, while the fourth is a 70 percent UVFLOOD from the set of images acquired for LWR ITF2 (but not actually used in LWR ITF2).

Using the extracted spectral file, the S/N was measured in various spectral regions of each spectral image processed with each of the three ITFs. Ten-point box-filtered means in 90A bandpasses and the rms dispersions about the means are shown in Table 1. As can be seen from the Table, in each case the best S/N was obtained for the normal ITF, the worst was with the 3x3 ITF, while the 2x2 was intermediate. The S/N in the 2x2 ITF was about seven percent worse than the normal ITF while that in the 3x3 was about 11 percent worse, on average.

The results of applying the three ITFs to the flat-field image are shown in Table 2. Shown are the standard deviations in several arbitrarily selected 12x12 pixel boxes in the PBI image (which contains scaled FNs). The noise level as measured by these standard deviations is about 14 percent worse using the 2x2 ITF than for the normal ITF and about 18 percent worse using the 3x3 ITF, on average.

The results strongly suggest that spatially smoothing the ITF degrades the S/N rather than improving it as had been hoped. If the ITF could be perfectly registered with the raw image, then it is clear that the normal, unsmoothed ITF should be best. It is the presumed misregistration of the image with the ITF that motivated the smoothing; thus, the results could be interpreted as suggesting that the registration is better than might have been expected. In order to check this hypothesis that the superior performance of the normal ITF is due to fairly good registration, a test was run in which the same flat-field image (LWR 17136) was intentionally de-registered by one pixel in both line and sample, then photometrically corrected with the normal ITF. As shown in Table 2, the S/N in this image was not only lower than in the properly registered image, but also poorer than if the same (properly registered) image is processed with the smoothed ITFs. This suggests that it is indeed the registration that is crucial in determining the S/N.

There are other effects that could help explain the poor results of smoothing the ITF. At various stages of the image processing, interpolation is performed which can be thought of as applying "effective smoothing" even in the nominally unsmoothed ITF. At least four such steps exist:

1) Several images are averaged to form each level of the ITF. These images are not perfectly registered with each other; the errors should be on the order of a few tenths of a pixel (Thompson, 1985).

2) The geometric correction of the raw ITF images involves a resampling and thus an effective smoothing of up to the equivalent of a 2x2 pixel filter. (A 2x2 pixel filter would correspond to the raw data point lying equidistant from the four neighboring ITF pixels.)

3) The application of the ITF involves an interpolation, again leading to an effective smoothing box of up to 2x2 pixels.

4) For spectral data, the extraction procedure resamples and thus smoothes the data.

These effects are by no means uniform across the image; the net result is a complicated variation of "effective smoothing box" size across the image. If the registration is good enough so that errors are typically smaller than the size of this box over most or all of the image, then further, "artificial," smoothing can only degrade the S/N and is therefore counter-productive. This is what appears to be occurring in the present case for both data images and flat-field images. It would also follow that using spatially-smoothed ITFs would not be advisable in production processing. This confirms the results of Northover (1981), who also reached the conclusion that smoothing the ITF (in this case for both the SWP and LWR cameras) led to no improvement in S/N of processed images.

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REFERENCES

Northover, K. 1981, unpublished report to IUE Three-Agency Meeting, "Smoothing the IUE ITFs."

Thompson, R.W. 1985, private communication.

Table 1

RMS Dispersion About the Mean of Spectral Data Processed with LWR ITF2 and Two Smoothed LWR ITFs (Units are FN)

	Normal ITF	2x2 ITF	3x3 ITF	Ratio of 2x2 to Normal	Ratio of 3x3 to Normal
LWR 17642					
2070-2160 A	1685	1784	1858	1.059	1.103
3010-3100 A	2077	2250	2332	1.083	1.123
LWR 17674					
2070-2160 A	2632	2685	2747	1.020	1.044
3010-3100 A	2571	2987	3174	1.162	1.235
LWR 17675					
1980-2070 A	1515	1604	1640	1.059	1.083
3010-3100 A	2144	2216	2254	1.034	1.051
Mean, Standard Deviation of the Sample				1.070±0.050	1.107±0.070

Table 2

Standard Deviations for Selected 12x12 Pixel Areas
in a Flat-Field UVFLOOD Image (LWR 17136) Processed
with LWR ITF2 and with Two Smoothed ITFs
(Units are FN/70)

	Normal ITF	2x2 ITF	3x3 ITF	Normal ITF (Deregistered)	Ratio of 2x2 to Normal	Ratio of 3x3 to Normal	Ratio of Normal(Deregistered) to Normal(Registered)
15,14	10.9	12.6	13.1	14.5	1.156	1.202	1.330
32,14	9.6	10.1	10.4	10.9	1.052	1.083	1.135
15,31	21.2	24.0	24.7	27.1	1.132	1.165	1.278
32,31	19.0	25.1	26.3	30.3	1.321	1.384	1.595
33,14	8.6	9.1	9.3	10.6	1.058	1.081	1.233
50,14	6.9	7.2	7.3	9.4	1.043	1.058	1.362
33,31	21.1	24.3	25.2	27.6	1.152	1.194	1.308
50,31	9.4	11.4	12.0	13.2	1.213	1.277	1.404
33,32	19.7	23.0	23.8	27.9	1.168	1.208	1.416
50,32	9.6	10.8	11.3	13.3	1.125	1.177	1.385
15,49	17.1	20.9	21.7	23.5	1.222	1.269	1.374
32,49	20.2	21.7	22.2	24.3	1.074	1.099	1.203
Mean, Standard Deviation of the Sample					1.143 ±0.082	1.183 ±0.096	1.335 ±0.119

Notation: 15,14 means line 15, sample 14 in "BOXSTAT" coordinates, which are line or sample divided by 12