A Richardson-Lucy Algorithm Using A Varying Point Spread Function Along The Iterations

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Image restorations with the Richardson-Lucy [1-2] algorithm suffer the drawback imposed by the constraint of a constant *Point Spread Function – PSF* as unfolding function. Indeed, as the iterations proceed, the overall resolution is improved while the PSF is kept constant. This mismatch is *eliminated* in this work by reducing the PSF width as the iterations proceed. Such a procedure requires the resolution of the image so far achieved, which is performed with an algorithm based upon the concept of *Global Contrast* (*G–value* for short) [3]. This algorithm is not tied to any type of acquisition system, as it uses solely the information provided by the image itself. The G–value increases with *w*, reaches a maximum, and then decreases again. The *w*–value yielding the maximum G is assigned as the *best* PSF width. The G-value is determined as follows:

$$G = \left[\sum_{i=1}^{M}\sum_{j=1}^{N} u(i,j).\beta(i,j)\right].\left[\sum_{i=1}^{M}\sum_{j=1}^{N} u(i,j).\left|1-\beta(i,j)\right|\right]^{-1} \quad (1)$$

$$\beta(i,j) = 0 \quad \text{for} \quad u(i,j) \le u_m \quad (2)$$

$$\beta(i,j) = 1 \quad \text{for} \quad u(i,j) > u_m \quad (3)$$

$$u_m = (M.N)^{-1}.\sum_{i=1}^{M}\sum_{j=1}^{N} u(i,j) \quad (4)$$

where:
$u(i,j)$ = Pixel value at the point $(i\ ,j)$.
M, N = No. of columns and lines of the image matrix.
After equation (4), u_m is the average pixel–value used to classify all pixels into two classes: below and above it. The sums of all pixel–values occurring above and below u_m constitute the numerator and denominator of equation (1) respectively, defining the G-value, while the bump function $\beta(i, j)$) classifies the pixel–values as below or above u_m. A higher fraction of pixels at darker and brighter zones means a higher contrast arising from a better resolution. Therefore, the sum of all pixel–values above u_m would increase while that below it would decrease, resulting into a higher G-value. Further details can be found elsewhere [4].

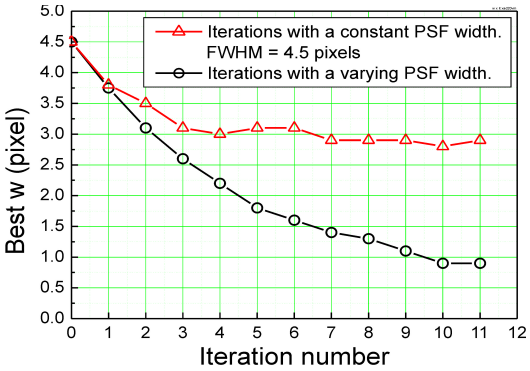

Figure 1. Behavior of *constant* x *varying* PSF.

As shown in Figure 1, the PSF drops faster for the varying approach demonstrating its higher effectiveness. The deconvolved gamma-ray radiographs in Figure 2 corroborate this outcome.

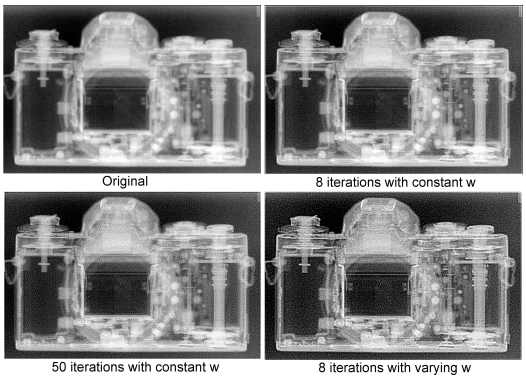

Figure 2. Original and unfolded images. Eight iterations with a varying *PSF* outperform those with a constant value, even for 50 iterations.

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