

ANALOG IMAGE PROCESSING IN TWO DIMENSIONS BY OMNIDIRECTIONAL SCANNING

In their article Nahara, et al (1) give entirely too much credit to me and not enough to others in discussing scanning rasters for two-dimensional image manipulation.

The reference in my original article (2) indicated that the most detailed and now classical treatment of this subject was given by L. S. G. Kovaszny and H. M. Joseph in 1955 (3). These two investigators show that two-dimensional isotropic scans "can be performed in several ways":

1. The central portion of a Lissajous figure formed by two sine waves may be employed. However, the requirements are approximately satisfied over only a small central portion.
2. An interlacing raster of curves such as cycloids or spirals.
3. A conventional television scan rotated 90 deg after each frame is completed.
4. Symmetrical triangular waves of slightly different frequencies for horizontal and vertical deflections. The resulting Lissajous figure consists of straight lines and, if operated slowly, has the appearance of a slowly varying rectangle.

The authors have obviously rediscovered Method 4 while what they call "Gregg's method" is really Method 3. At the time my paper was presented, I emphasized a slight variation of Method 3 because

of its potential for producing apparent live-time manipulations utilizing short-time integration by the eye. On the other hand, Methods 1 and 4 as used to date have required long-time (photographic) integration to produce a usable image. In spite of the authors' criticisms concerning the lack of raster rotation in "Gregg's method", Method 3 will still produce an isotropic scan. In fact, all methods previously discussed should give the same results if performed properly.

In their original paper, Kovaszny and Joseph also showed images processed by Method 4 while R. W. Brainard and G. N. Ornstein reported on Method 1 in 1965 (4). Method 1 is also the raster used in the commercial Logetronic system.

Regardless of the lack of proper credits, the authors are to be congratulated for presenting a well-detailed working analog system for rescanning of scintiscans. It is most interesting that they also confirm the necessity of a fair amount of initial smoothing (spatial averaging or blurring) prior to image manipulation presumably because of the low signal-to-noise levels in the original data. Comments by the authors as to the amount of blurring necessary to subsequently deblur would have been most welcome.

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THE AUTHORS' REPLY

We appreciate the remarks concerning the author's credits for the related works. We regret that we have omitted Kovaszny and Joseph's paper (3) from our references due to the simple reason that Dr. Gregg introduced their classical work quite well in the process of scintigraphic images.

The second point of Dr. Gregg's comments is concerned with his statement that the two-dimensional isotropic scan can be performed by their methods, for instance, the Method 3 in his comments, without raster rotation. We do not feel it is reasonable, how-

ever, to make the statement without clarifying the assumption on which the statement is based since the Method 3 is "isotropic" only for a special type of processing, as described precisely in the original paper (3).

According to the paper, letting $f(x,y)$ and $F(x,y)$ be the original and the processed image, respectively, they assumed that the resultant image F depends only on the behavior of f in the infinitesimal neighborhood of point (x,y) . Then an isotropic operation is expressed by