

# Correcting for Short-Range Spatial Non-Linearities of CRT-based Output Devices

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## ABSTRACT

Most graphical output devices exhibit what has been termed spatial non-linearity: the effect of setting two adjacent pixels to a given value is not the same as the sum of the effects of setting those two pixels to the same value in isolation: checkerboards of different frequencies do not have the same apparent luminance. We present a method applicable to bit-mapped devices for compensating for short-range spatial non-linearity in error-diffused images. The modification to error diffusion is such that it can be used with any error diffusion technique. In essence, it consists of finding the influence of the neighbouring (output) pixels when making the decision of whether to turn on a given pixel, and passing errors computed accordingly.

**CR Descriptors:** B.4.2 [Input/Output and Data Communications]: Input-Output Devices - *Image Display*; I.3.1 [Computer Graphics]: Hardware Architecture - *Raster display devices* I.3.3 [Computer Graphics]: Picture/image generation - *Display algorithms*; I.3.6 [Computer Graphics]: Methodology and Techniques; I.4.3 [Image Processing]: Enhancement.

## INTRODUCTION

While the full-colour display is becoming more and more common, bit-mapped CRTs remain commonplace as well. These have advantages in terms of speed, resolution, and cost that cannot be matched by colour displays. Occasionally it is necessary to display an image on such a device. Moreover, certain colour-table animation techniques rely on the use of single bit-planes of a full-colour display. Here the full-colour display is being used to simulate a bit-mapped display with a very fast frame update rate. A common method of converting from full-colour continuous tone to black and white binary is to error diffuse the luminance component. Various forms of error diffusion have been suggested [1]; the particular choice of error diffusion technique has relatively little effect on the appearance of an image when it is displayed on a sufficiently high-resolution monitor.

The value of gamma-correction of colour displays (or better still instrumented compensation), is well known. On a bit-mapped display the concept of gamma-correction is meaningless. As Naiman

has noted, CRTs exhibit spatial non-linearities [2], as can be easily seen by displaying a checkerboard of period two pixels adjacent to a checkerboard of twice that period. When viewed from a sufficient distance to cause the coarser checkerboard to appear smooth, these two images should ideally appear the same intensity. On most output devices they do not. (An LCD display may be an exception).

Figure 1: A small gray box.

## References

- [1] J. Allebach. Binary display of images when spot size exceeds step size. *Applied Optics*, 15:2513–2519, August 1980.
- [2] E. Catmull. A tutorial on compensation tables. In *Computer Graphics*, volume 13, pages 1–7. ACM SIGGRAPH, 1979.

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