Pixels, Numbers, and Programs

Stereograms

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Outline

Motivation

Types of stereograms

Autostereogram construction

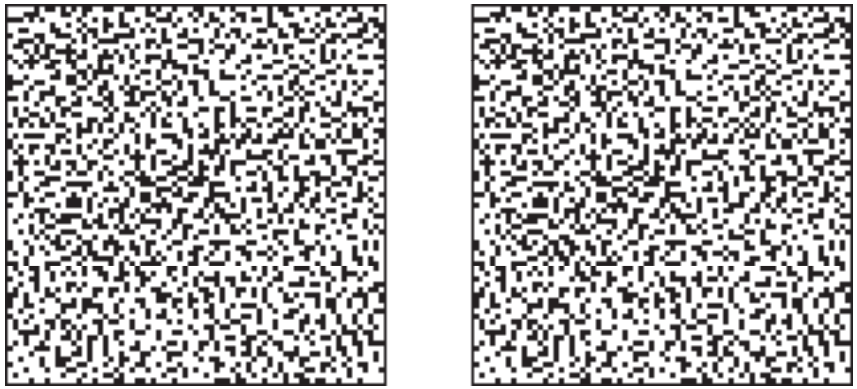
Motivation for Stereograms

- Entertainment (It's fun to look at 3D pictures and 3D movies)
- Communication of 3D content (education, advertising, research)
- Study human perception
- Treatment for visual disorders
- Study 3D computer vision
- Related to virtual reality

Types of Stereograms …

Two-view stereo photographs

Random Dot Stereograms

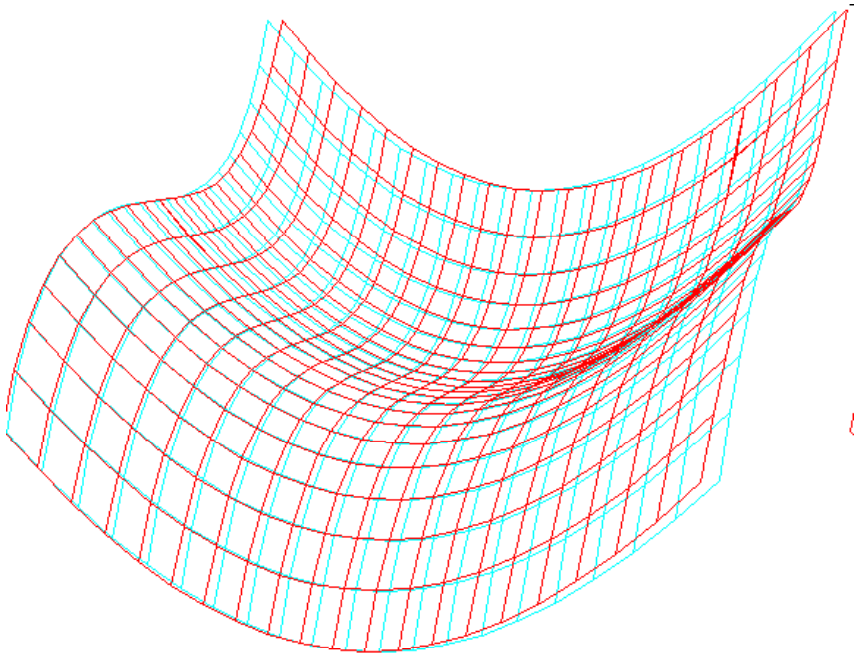


Studied by Bela Julesz at Bell Laboratories in the 1960s

Anaglyphs

Two monochrome images are colored red and green (or blue), respectively, and superimposed.

The anaglyph must be viewed with special (red-green) glasses.



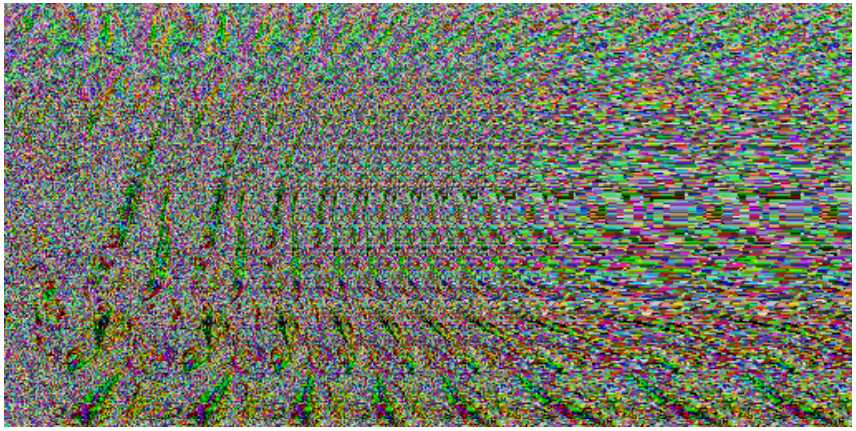
Source: Wikipedia commons.

Autostereograms

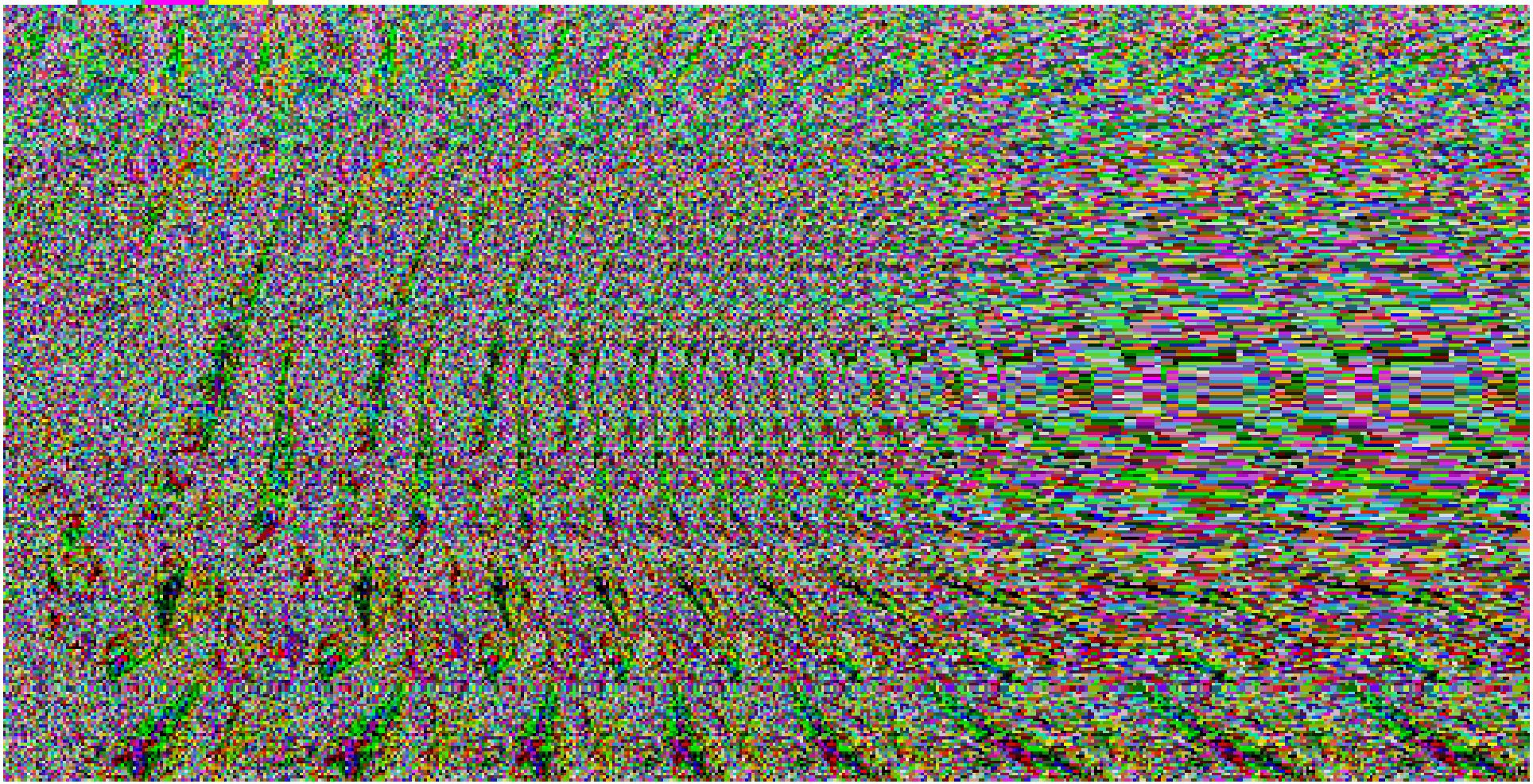
One image of a repeating texture

Modulated according to stereo disparity values.

"Magic Eye" pictures.



S. Tanimoto – created with PixelMath



Basic Autostereogram Constructions

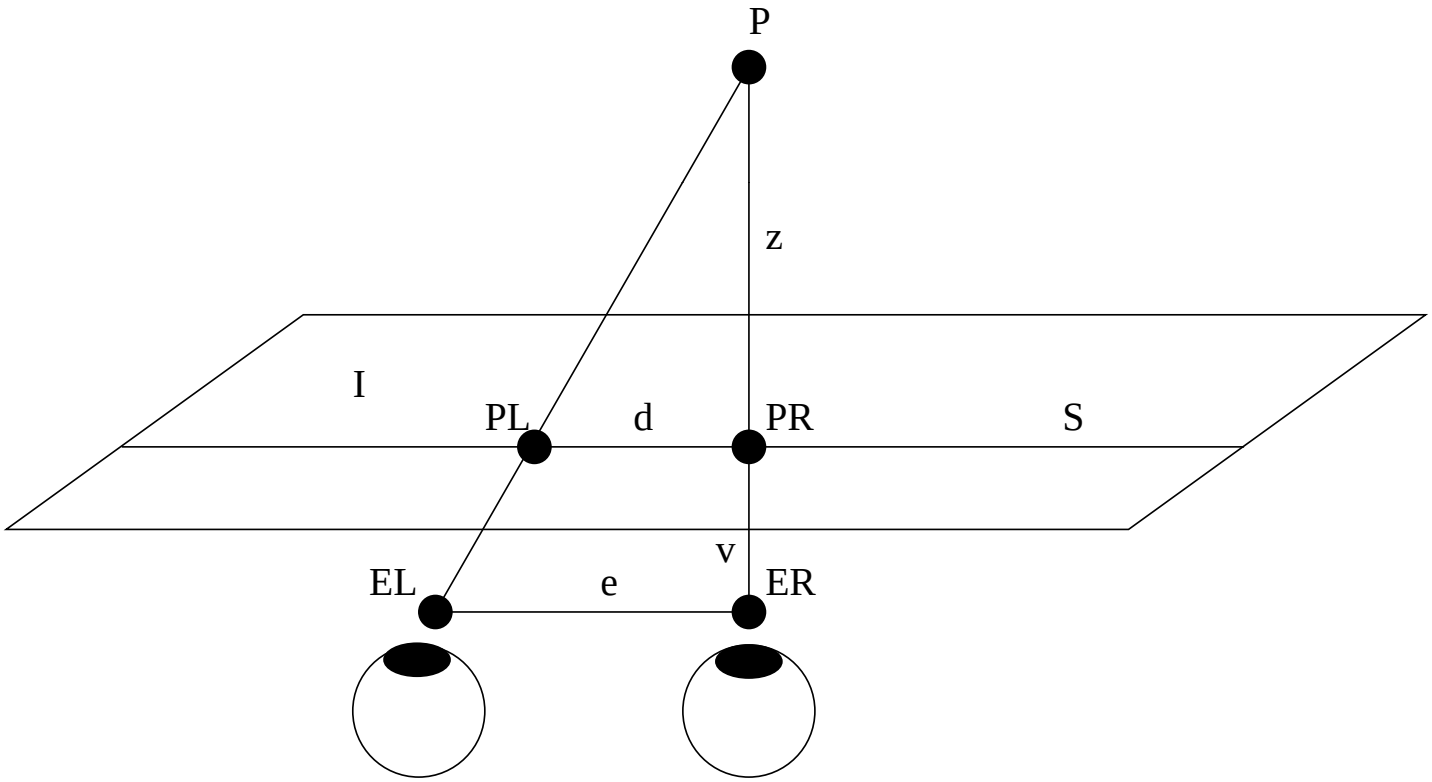
You need:

1. One depth map to be the hidden 3D “image”

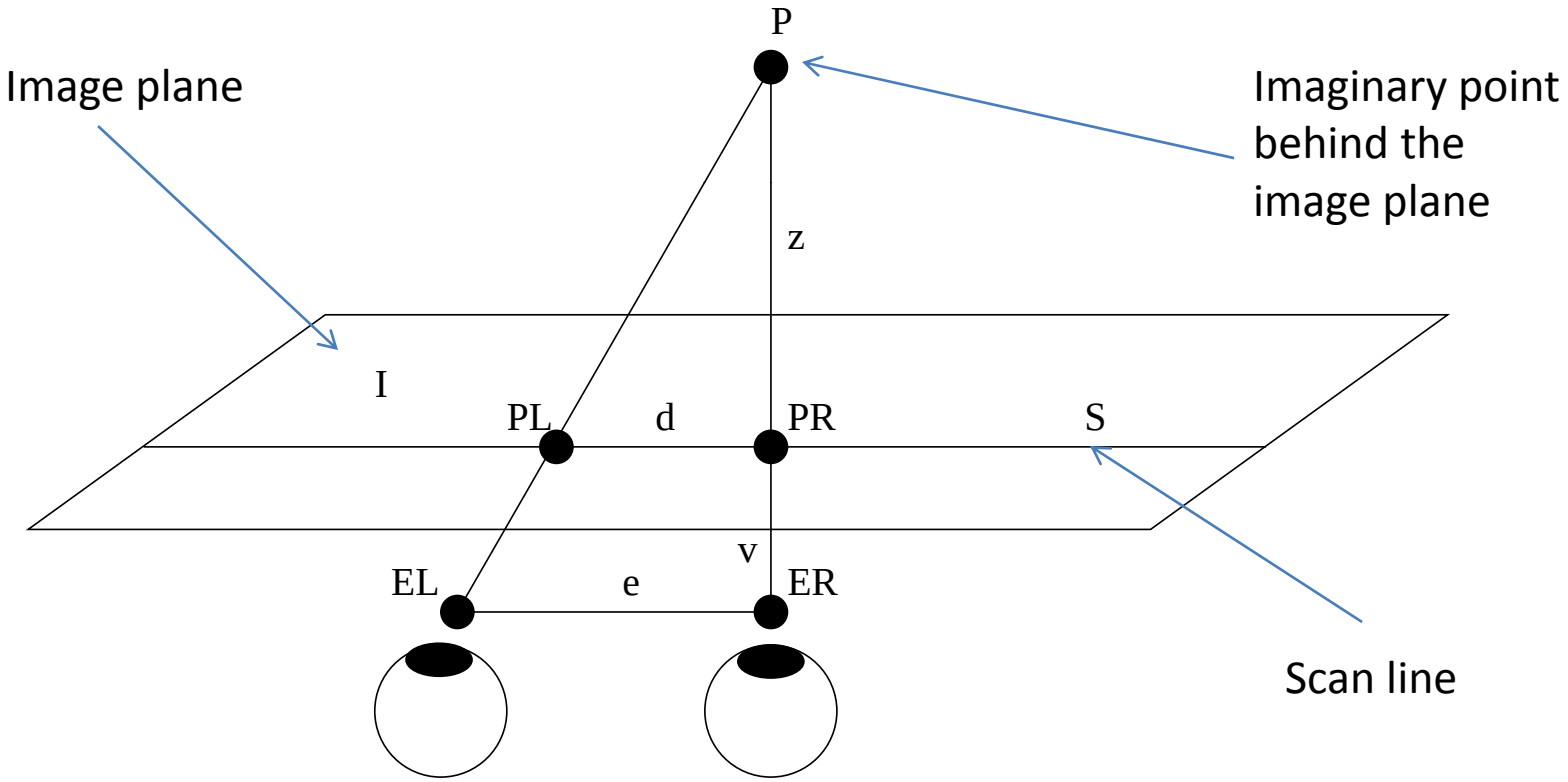
2. One textured image to be the carrier.

3. Formula for constructing the stereogram with PixelMath.

Geometric Relationships

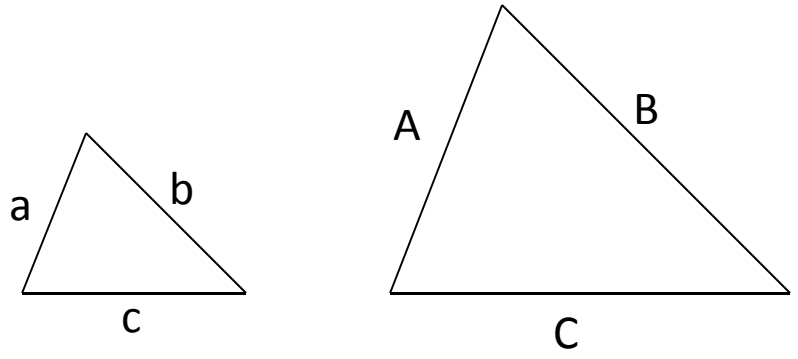


Geometric Relationships



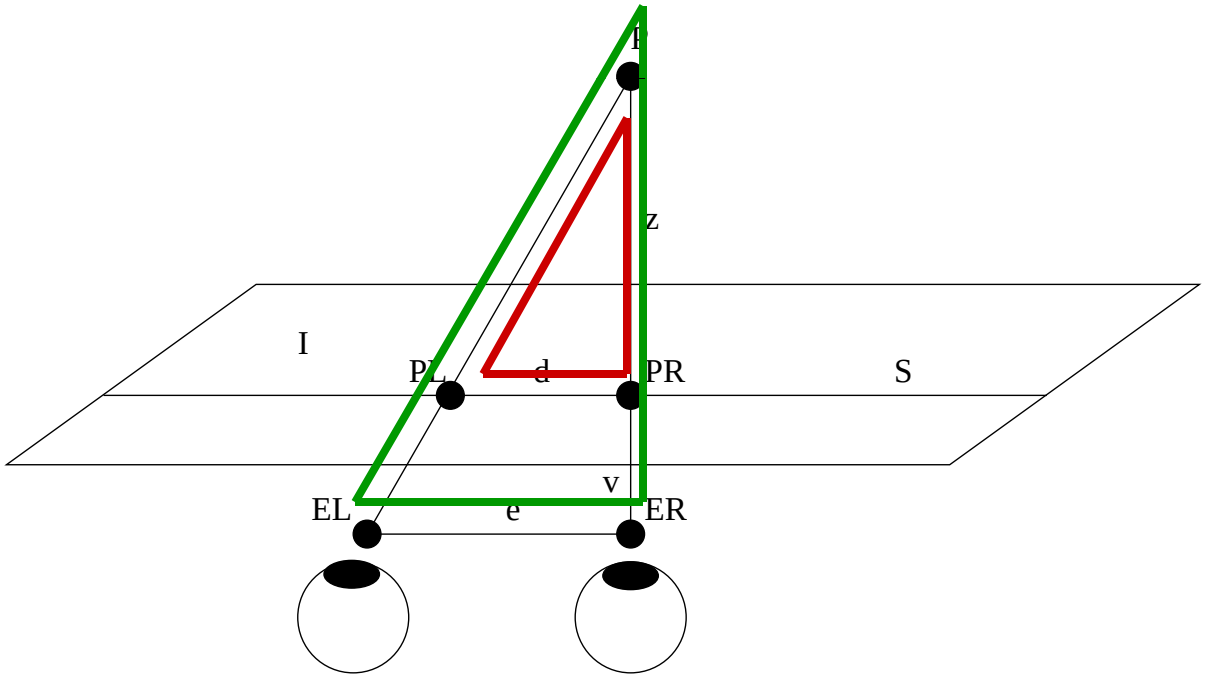
Similar Triangles

- Two triangles are called *similar* if their corresponding angles are equal.
- The ratio of two sides in one triangle equals the ratio of the corresponding sides in the other triangle.
- a/b = A/B
- b/c = B/C
- c/a = C/A



Similar Triangles in Stereogram Constructions

$$d/z = e/(z+v)$$



Similar Triangles in Stereogram Constructions

d/z = e/(z+v)

Solve for d:

d = e z / (z+v)

Use reasonable values:

e = 200	the interocular distance
z = S1(x,y)	value in the depth image
v = 1000	viewing distance (about 1 foot)

Stereogram Formula Part

d = e z / (z+v)	disparity (= displacement)
e = 200	the interocular distance
z = S1(x,y)	value in the depth image
v = 1000	viewing distance (about 1 foot)

So we have d =

(200 * S1(x,y) / (S1(x,y)+1000))

Stereogram Formula Body

If x – *d* < 0 then s2(x,y) else dest(x – *d*, y)

Substitute for d:

If x – (200 * S1(x,y) / (S1(x,y)+1000)) < 0

then s2(x,y)

else dest(x – (200 * S1(x,y) / (S1(x,y)+1000)), y)

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This assumes:

The PixelMath image processing engine is writing pixels in left-to-right order. (True unless you change the scanning order using a Python function.)

The carrier image, Source2, has height at least that of the depth map. If not, use "mod h2" to repeat the carrier image vertically.

The carrier image, Source2, has width at least e, which is the interocular distance. If not, use "mod w2" to repeat carrier pixels horizontally.

A Variation on the Implementation

Let's start again with this plan for a formula:
If x – *d* < 0 then s2(x,y) else dest(x – *d*, y)

Instead of substituting for *d* this expression:
(200 * S1(x,y) / (S1(x,y)+1000))
precompute *d* in another window; then substitute for *d* this:
S1(x,y)
The final formula is then
If x – S1(x,y) < 0 then S2(x,y) else dest(x –S1(x,y), y)

This makes the same assumptions about the carrier image.
You end up with shorter (though more) formulas.
It's easier to "tune" the stereogram with this method.

A Variation on the Implementation

Another advantage of the variation:

PixelMath's interpolation does not have to be turned off,

because all *d* values get "floored" when they are stored in the separate displacement image buffer.

Tips for Good Stereograms

"Good" means "easy to perceive the 3D effect."

The depth map should not be "busy" but have a relatively small number of distinct features, each of which is large enough to be seen – taking up at least several pixels in width.

The carrier image should be (a) highly textured, or at least contain sharp contrasts, and (b) should not itself be periodic horizontally (due to the possibility of the viewer locking in on disparities based on the wrong number of cycles of the carrier texture in the stereogram).

Artistic considerations are another matter.