A Guided Tour of Computer Vision

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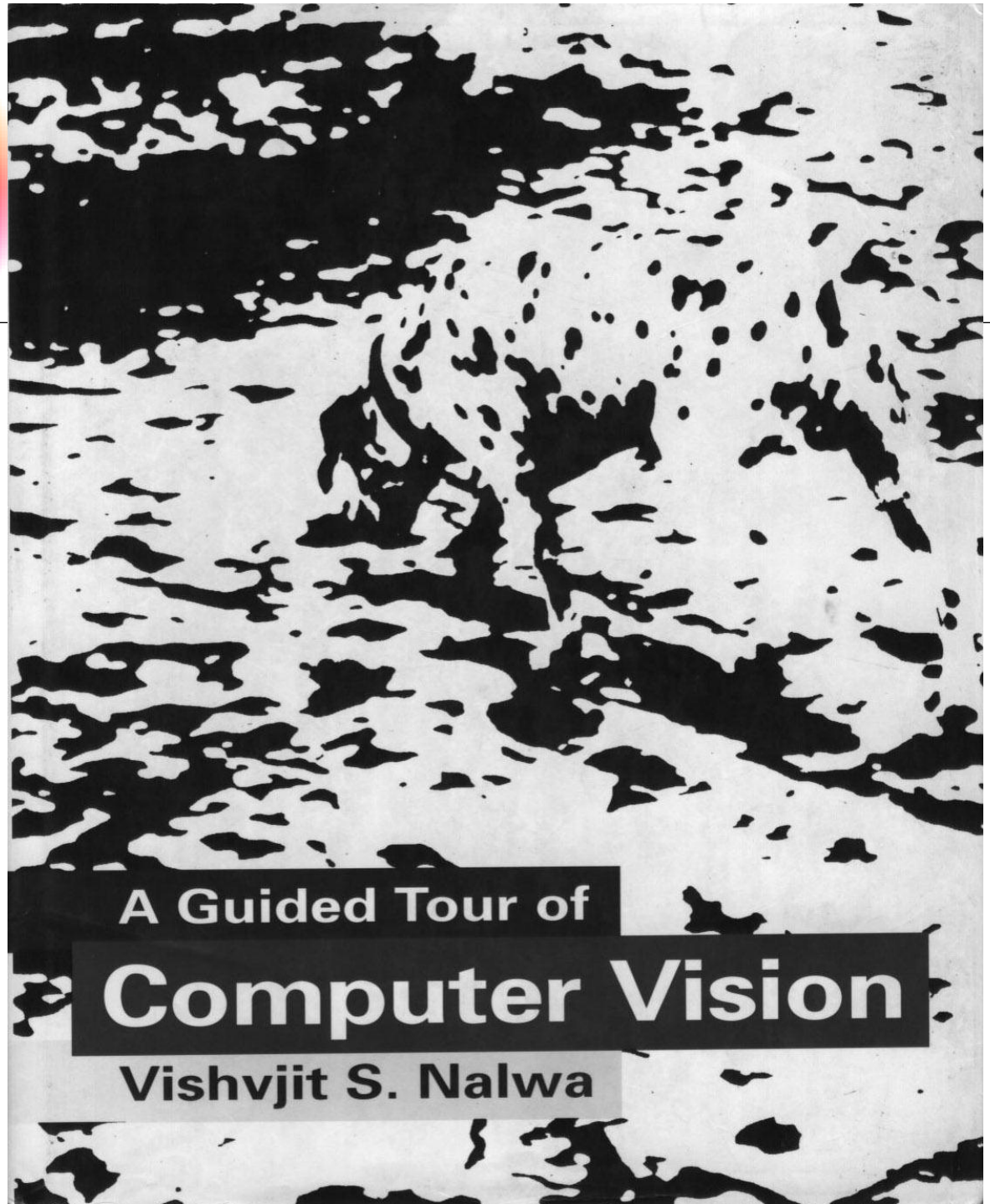

A Guided Tour of
Computer Vision
Vishvjit S. Nalwa

Can you see anything in this picture?

Introduction

- computer vision:

  image understanding: automatic deduction of structure and properties of 3D world from 2D world images

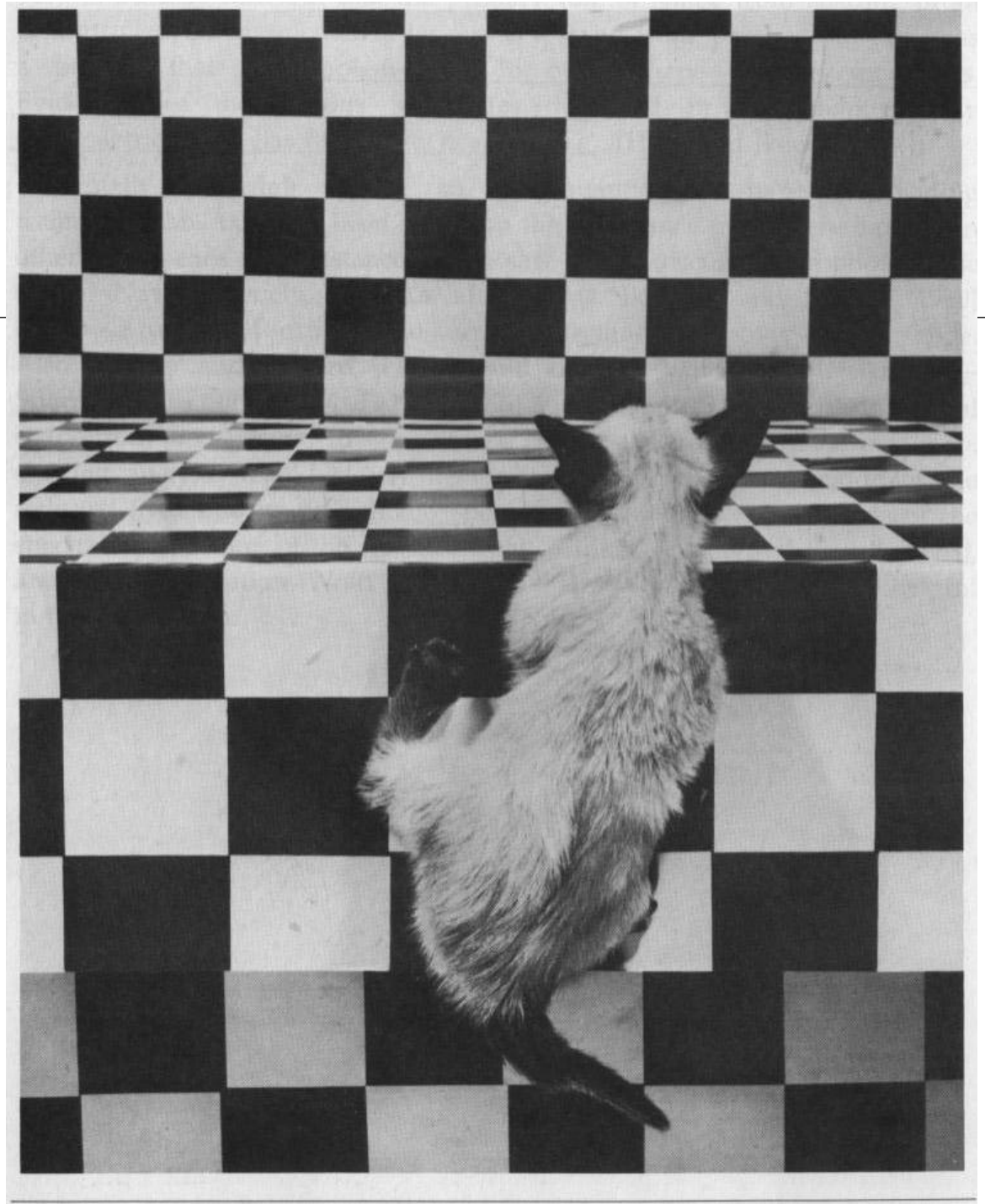
- computer graphics:

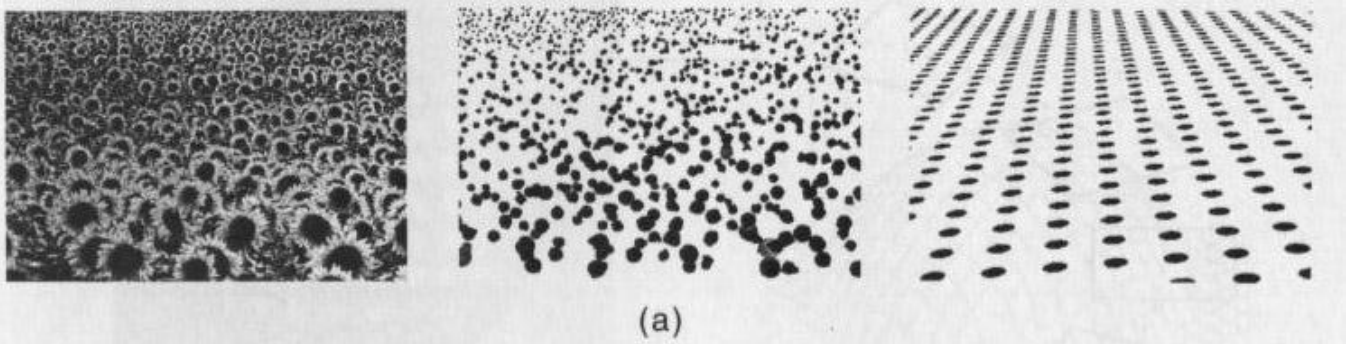
  visual synthesis: creates 2D images from 3D models photograph illustrating vanishing point

Figure 2.4 Photograph illustrating a vanishing point. Parallel straight lines converge at a single point under perspective projection. This point is called the *vanishing point* of the straight lines. (Photograph by Herbert Gehr, from the magazine *Life*, July 1947, © Time Warner, Inc.)

Shape from Texture

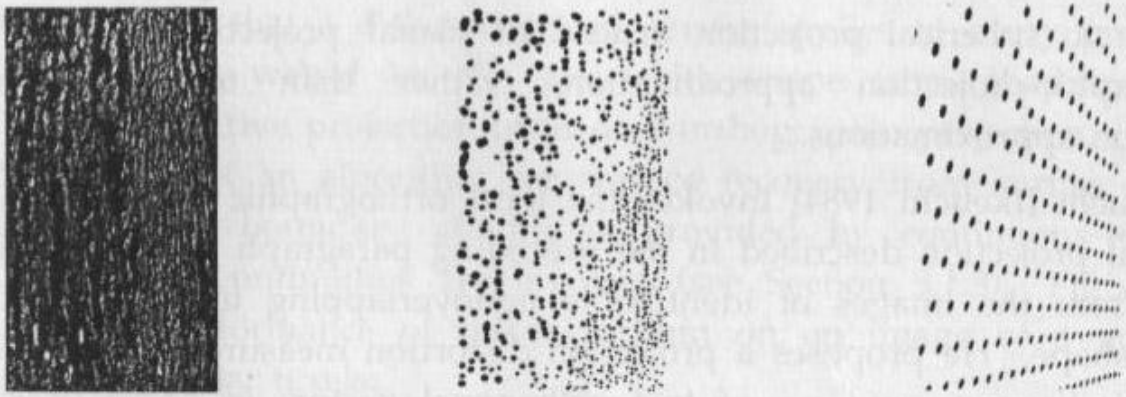
- results of integrated approach to identification of image texels





(a)

(b)



(c)

Shape from Texture (cont')

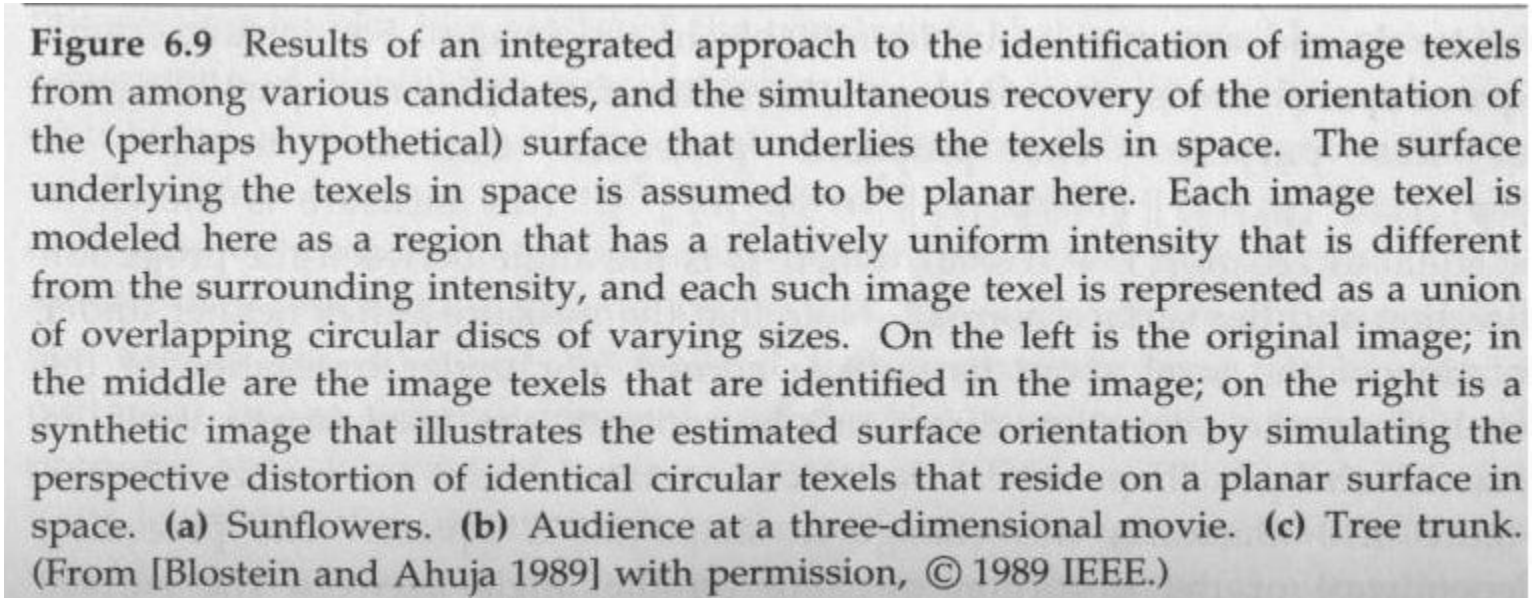


Figure 6.9 Results of an integrated approach to the identification of image texels from among various candidates, and the simultaneous recovery of the orientation of the (perhaps hypothetical) surface that underlies the texels in space. The surface underlying the texels in space is assumed to be planar here. Each image texel is modeled here as a region that has a relatively uniform intensity that is different from the surrounding intensity, and each such image texel is represented as a union of overlapping circular discs of varying sizes. On the left is the original image; in the middle are the image texels that are identified in the image; on the right is a synthetic image that illustrates the estimated surface orientation by simulating the perspective distortion of identical circular texels that reside on a planar surface in space. **(a)** Sunflowers. **(b)** Audience at a three-dimensional movie. **(c)** Tree trunk. (From [Blostein and Ahuja 1989] with permission, © 1989 IEEE.)

- visual cliff of Siamese kitten peering over checkered cliff

Shape from Texture (cont')

- shape of golf ball recovered from projective distortion of circular texels

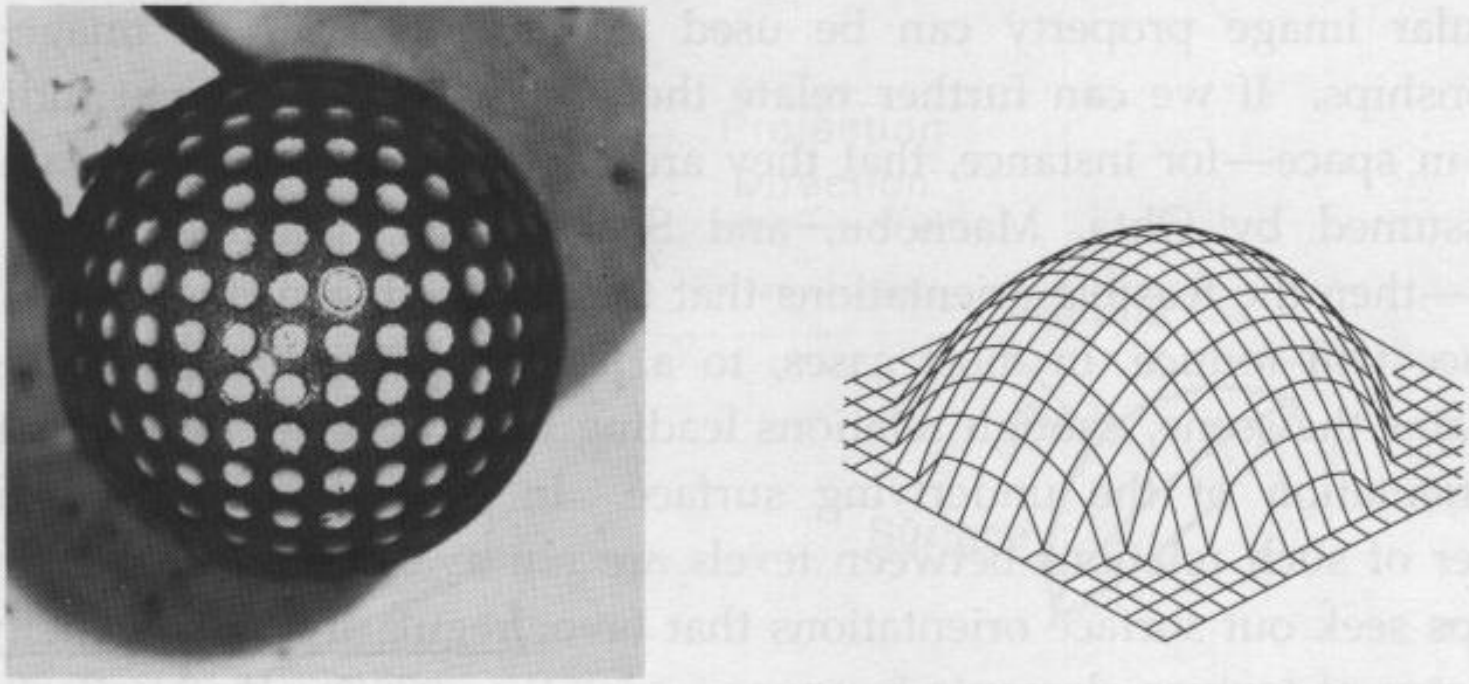


Figure 6.11 The shape of a golf ball recovered from the projective distortion of circular texels on the ball in space. On the left is an image of a golf ball that is covered with identical circular texels in space. On the right is the ball's shape recovered from the projective distortion of the texels on the ball. (From [Ikeuchi 1984] with permission.)

Shape from Texture (cont')

- image textural variation as cue to 3D shape

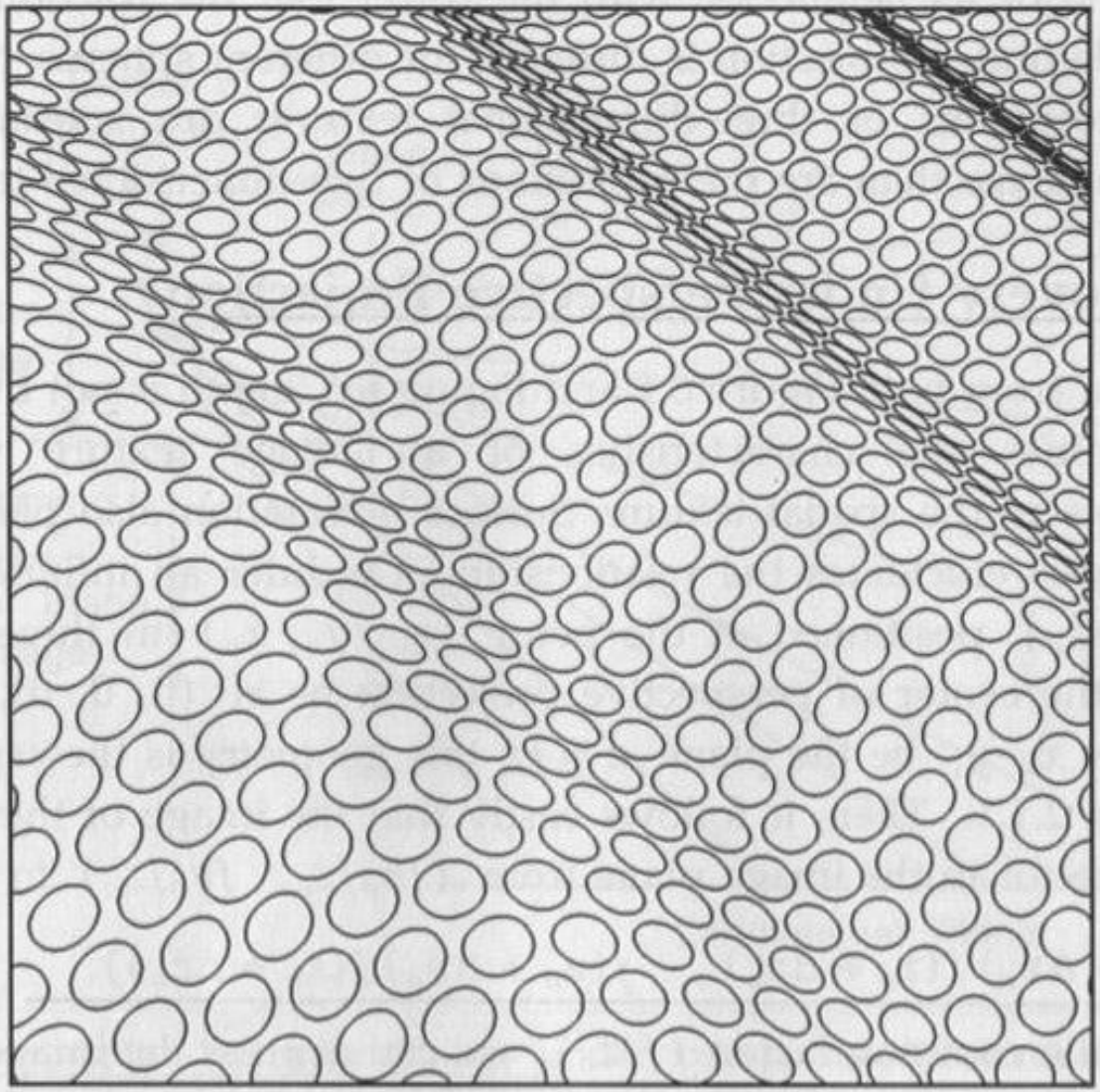


Figure 6.6 Image textural variation as a cue to three-dimensional shape. Variation in the image properties of a spatial texture often is a cue to three-dimensional shape. The illustrated distribution of ellipses of various shapes and sizes suggests a receding corrugated surface in space.

Shape from Texture (cont')

- 3D implications of discontinuities (a) depth discontinuity (b) two surfaces

Shape from Texture (cont')

- fractals: shapes exhibiting recursive self-similarity

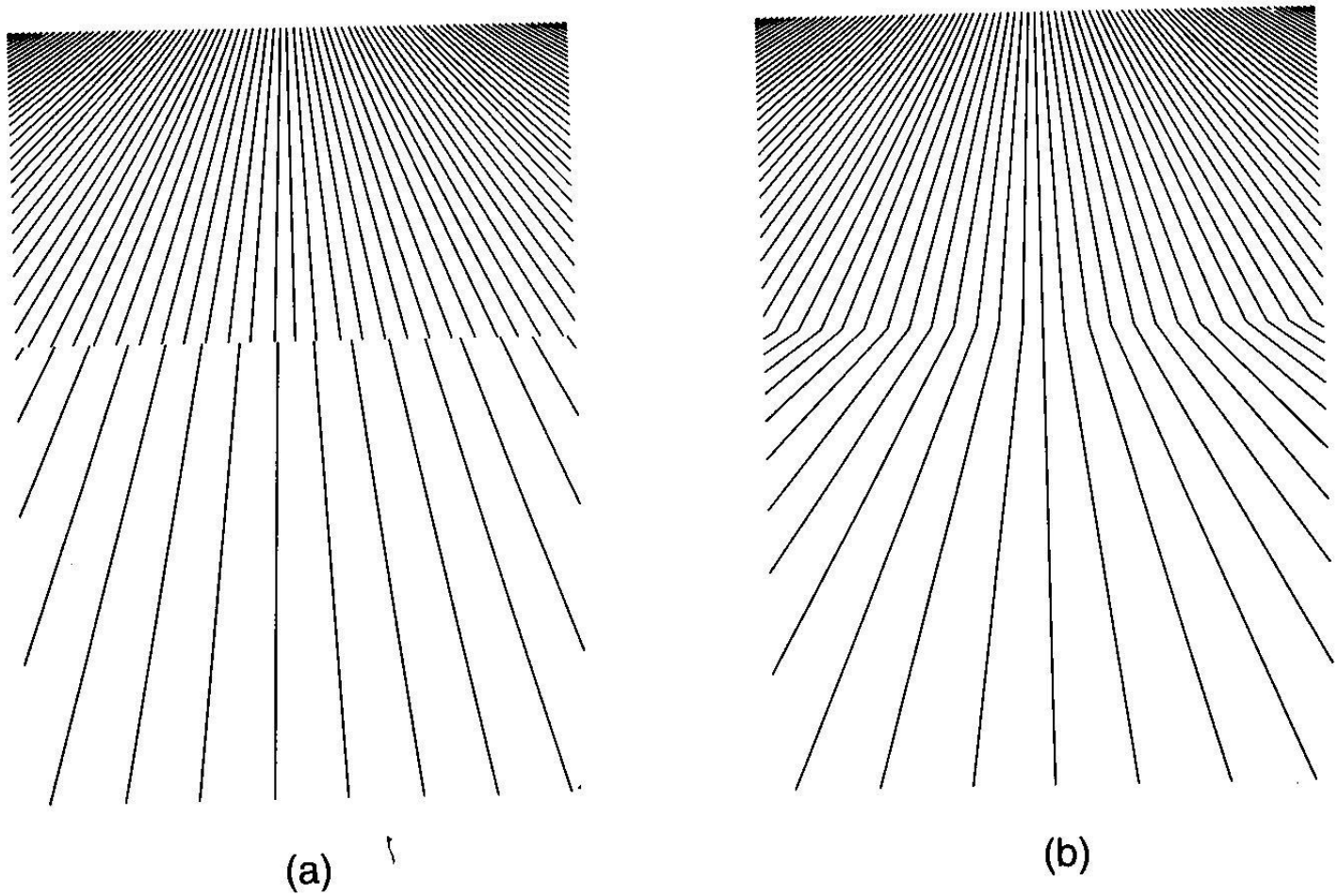
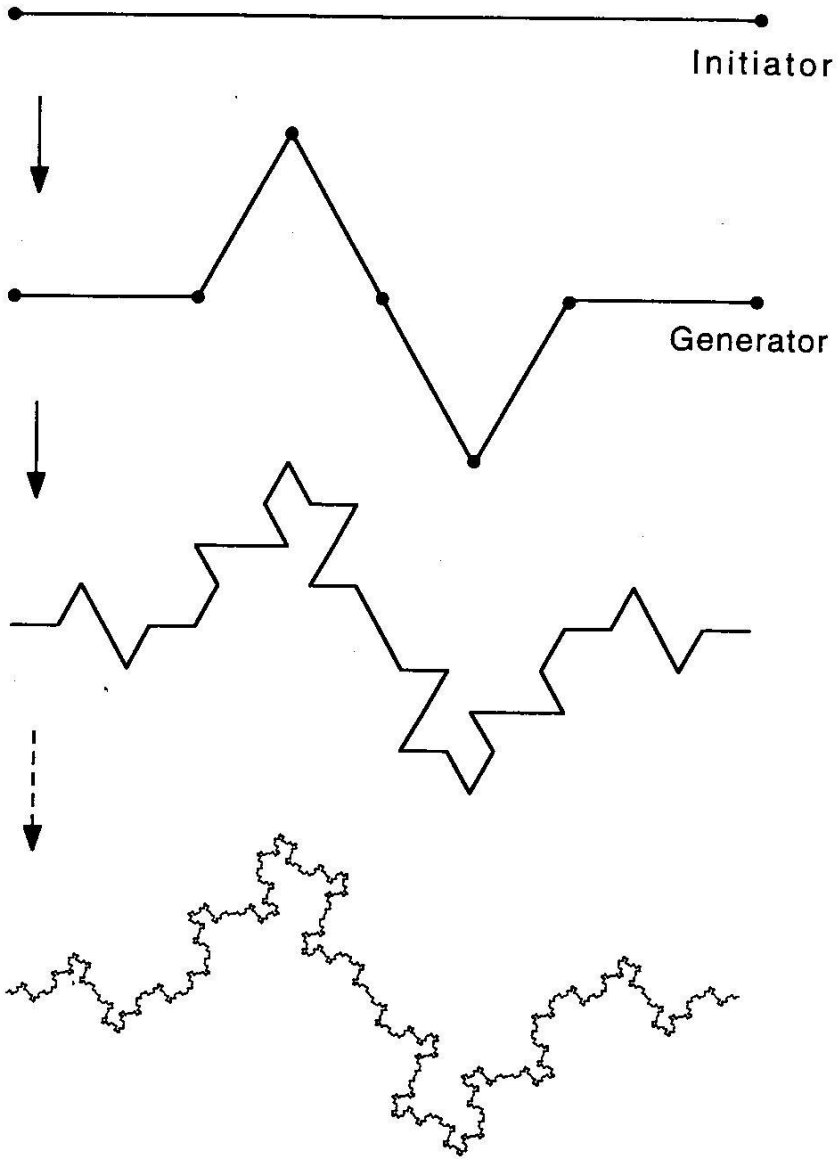


Figure 6.14 Three-dimensional implications of discontinuities in the image characteristics of a spatial texture. Discontinuities in the image characteristics of a spatial texture indicate surface discontinuities in space, assuming that these texture characteristics vary continuously over the imaged surface(s) in space. **(a)** A zeroth-

Shape from Texture (cont')

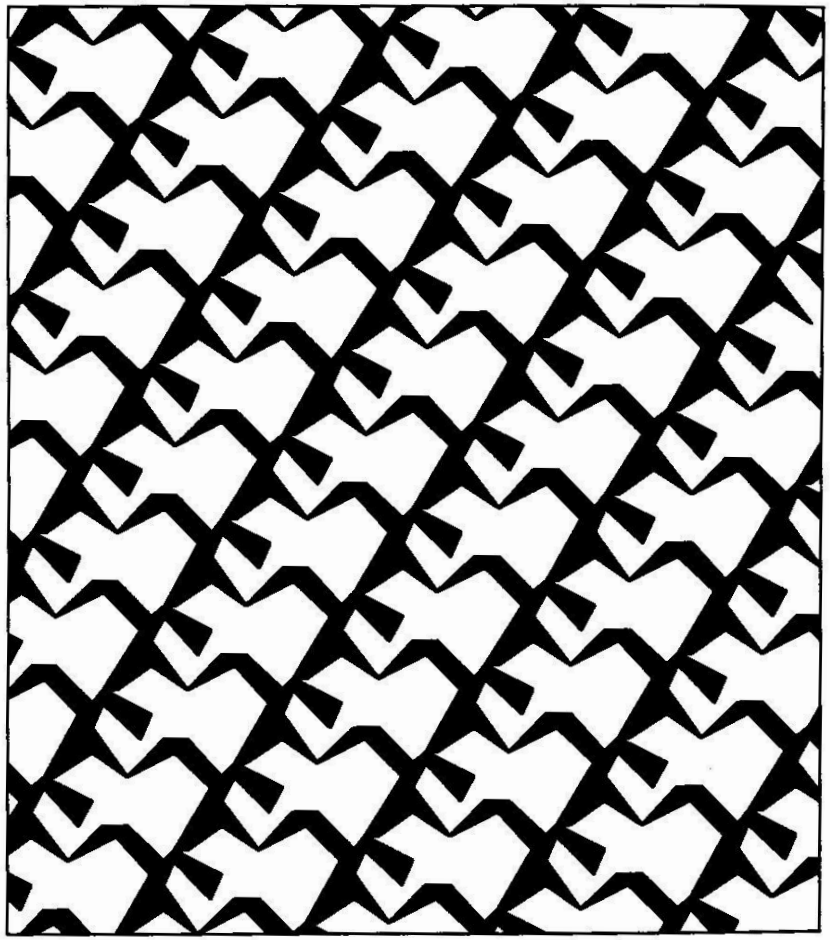
- Escher-inspired pattern with two texels (texture elements)

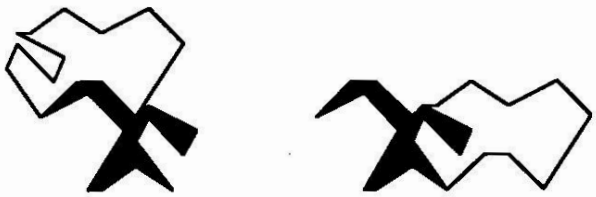


;ure 6.4 Fractals. *Fractals* are shapes that exhibit recursive self-simil
ctal can be recursively subdivided into smaller nonoverlapping sha
uich is a scaled-down version of the whole, either in a deterministic s
tistical sense. Equivalently, fractals are shapes that, in principle, can l
the recursive "subdivision" of a geometric shape, called the *initi*

Shape from Texture (cont')

- textures (a) water (b) beach pebbles (c) raffia weave (d) brick wall





Candidate Texels

6.5 An Escher-inspired pattern with two of several possible candida

Shape from Texture (cont')

- texture segmentation

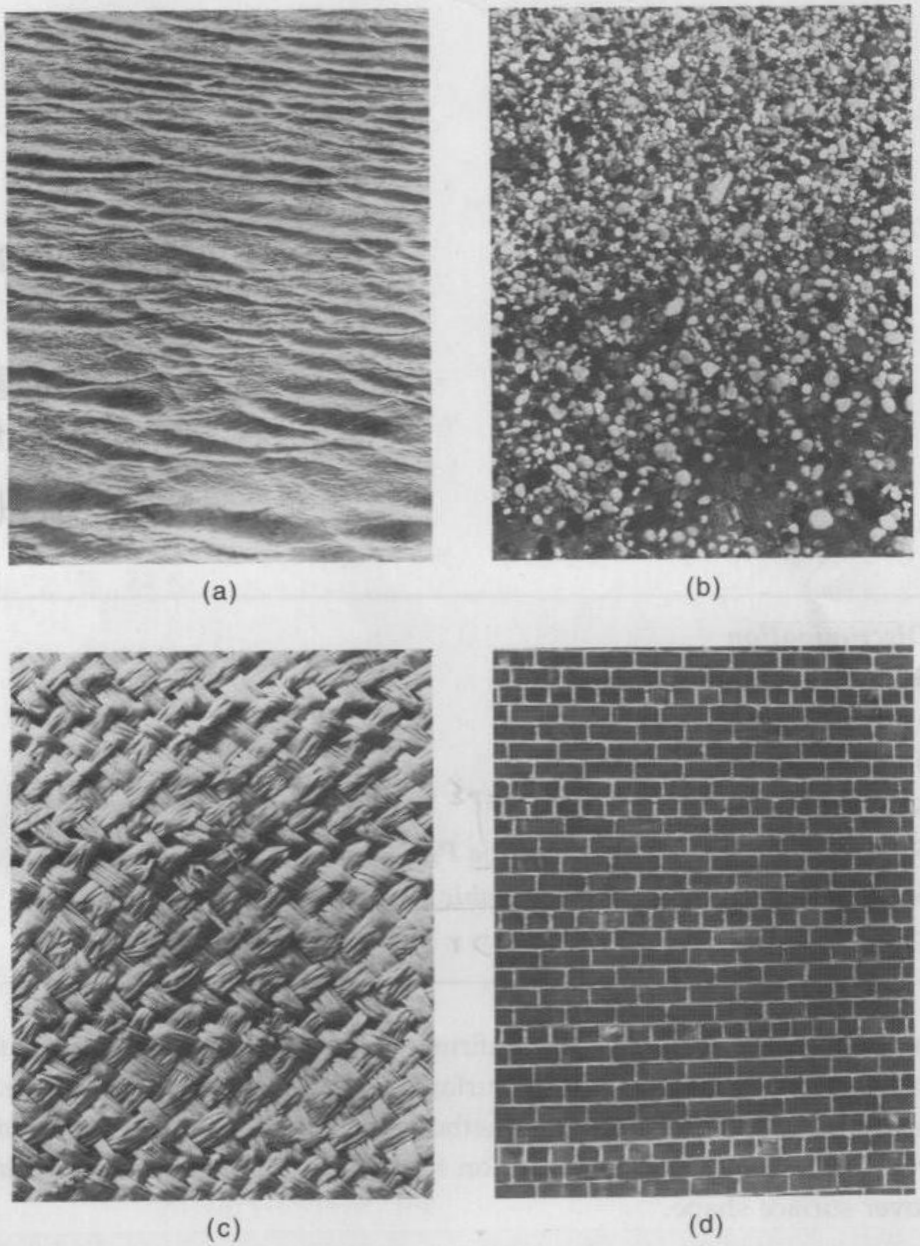
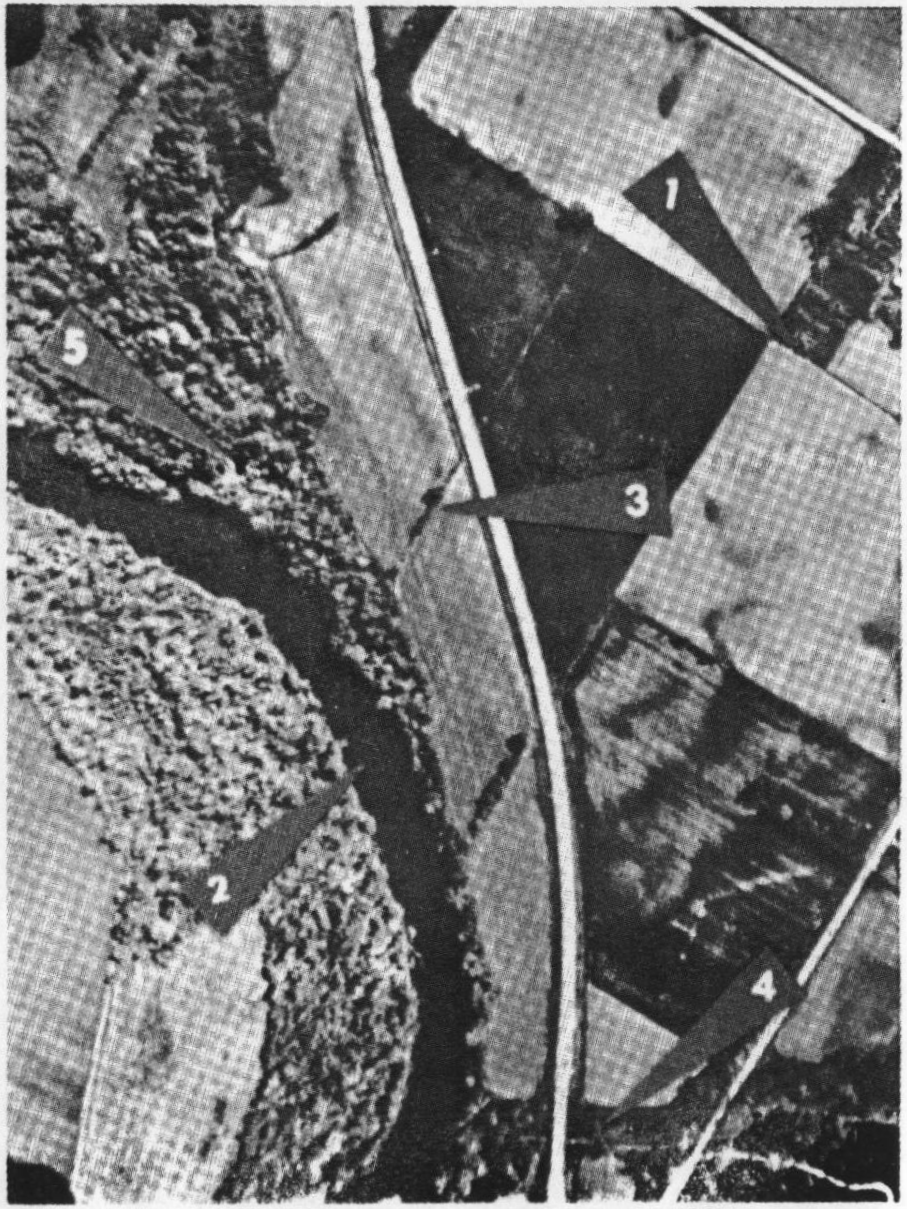
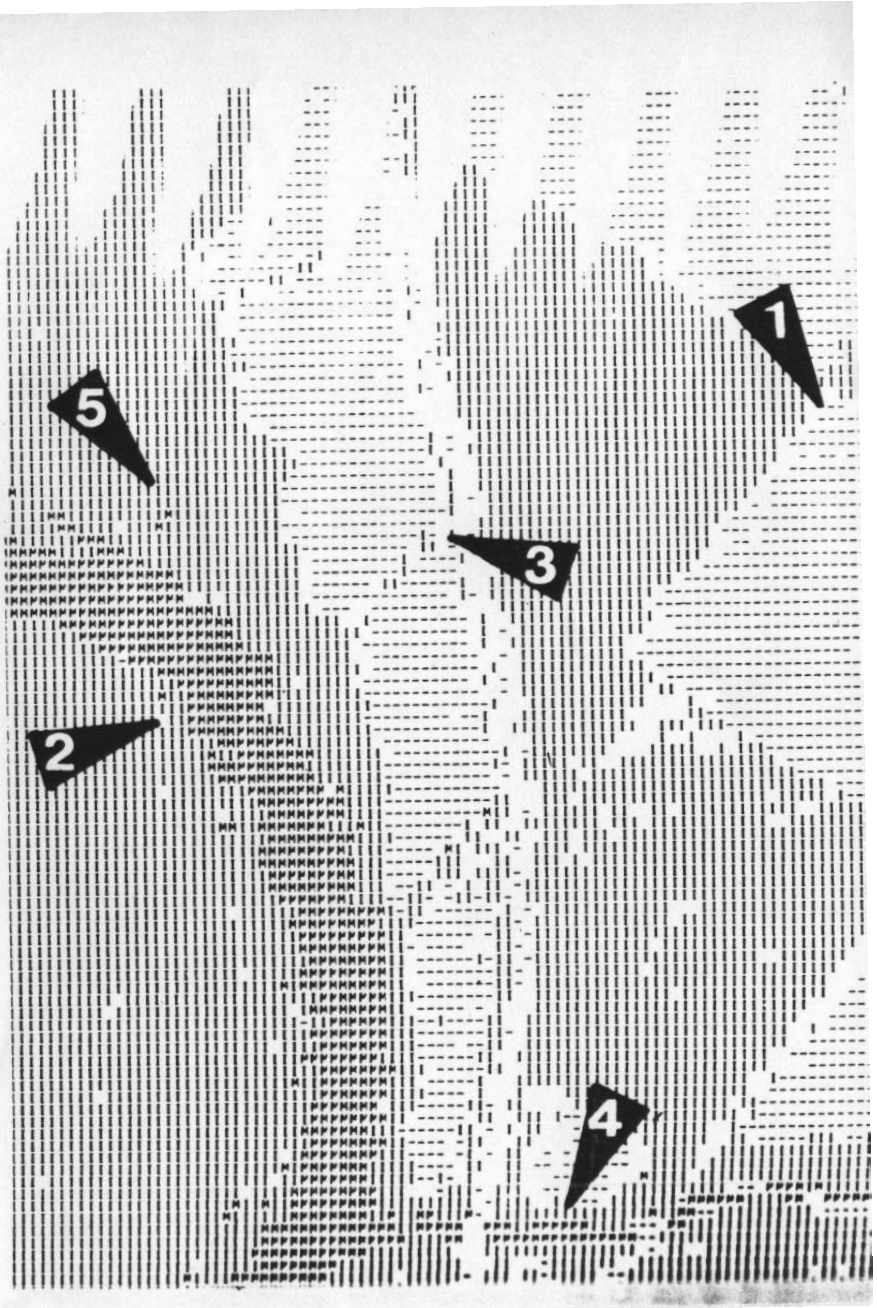


Figure 6.2 Our richly textured visual world. **(a)** Water. **(b)** Beach pebbles. **(c)** Raffia weave. **(d)** Brick wall. (From [Brodatz 1966] with permission.)

Shape from Texture (cont’)

- ======experiment: take pen cap off, put cap back with one eye======


1
5
3
2
4


1
5
3
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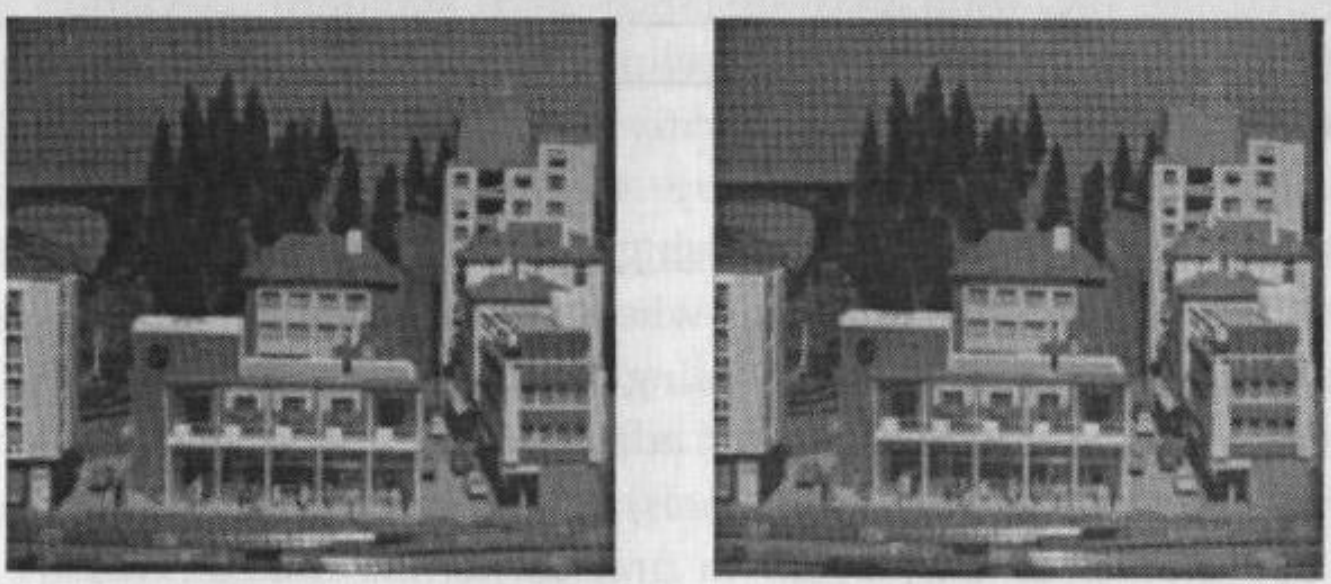
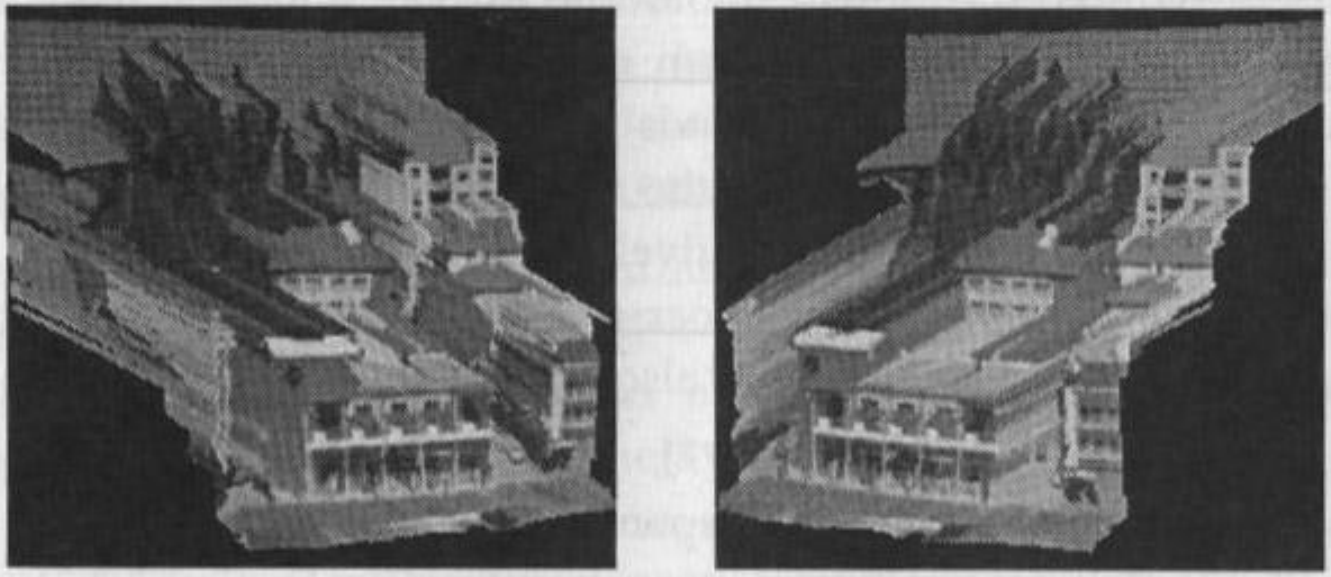
Shape from Stereo

- scene recovered from pair of stereo images



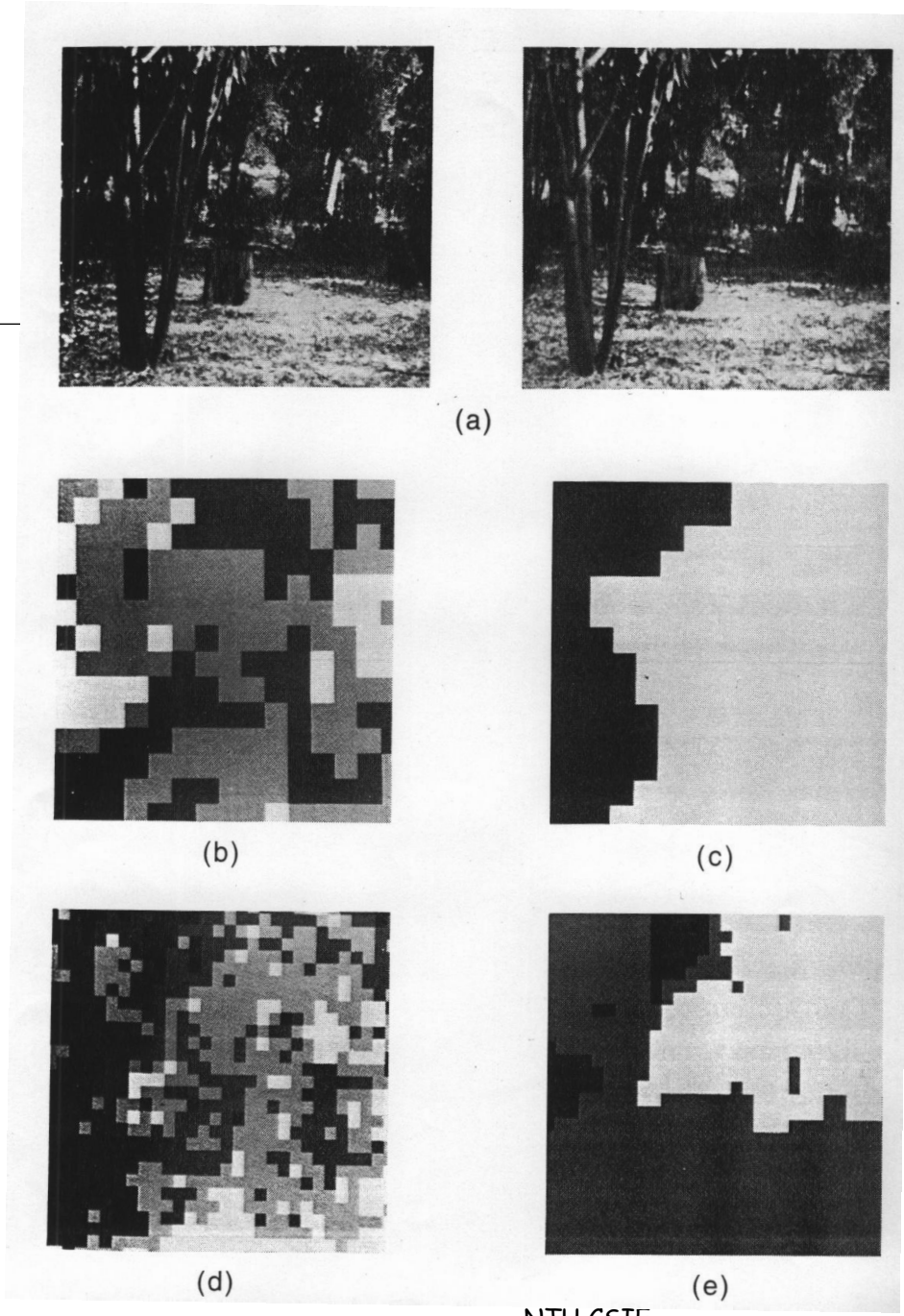
(a)

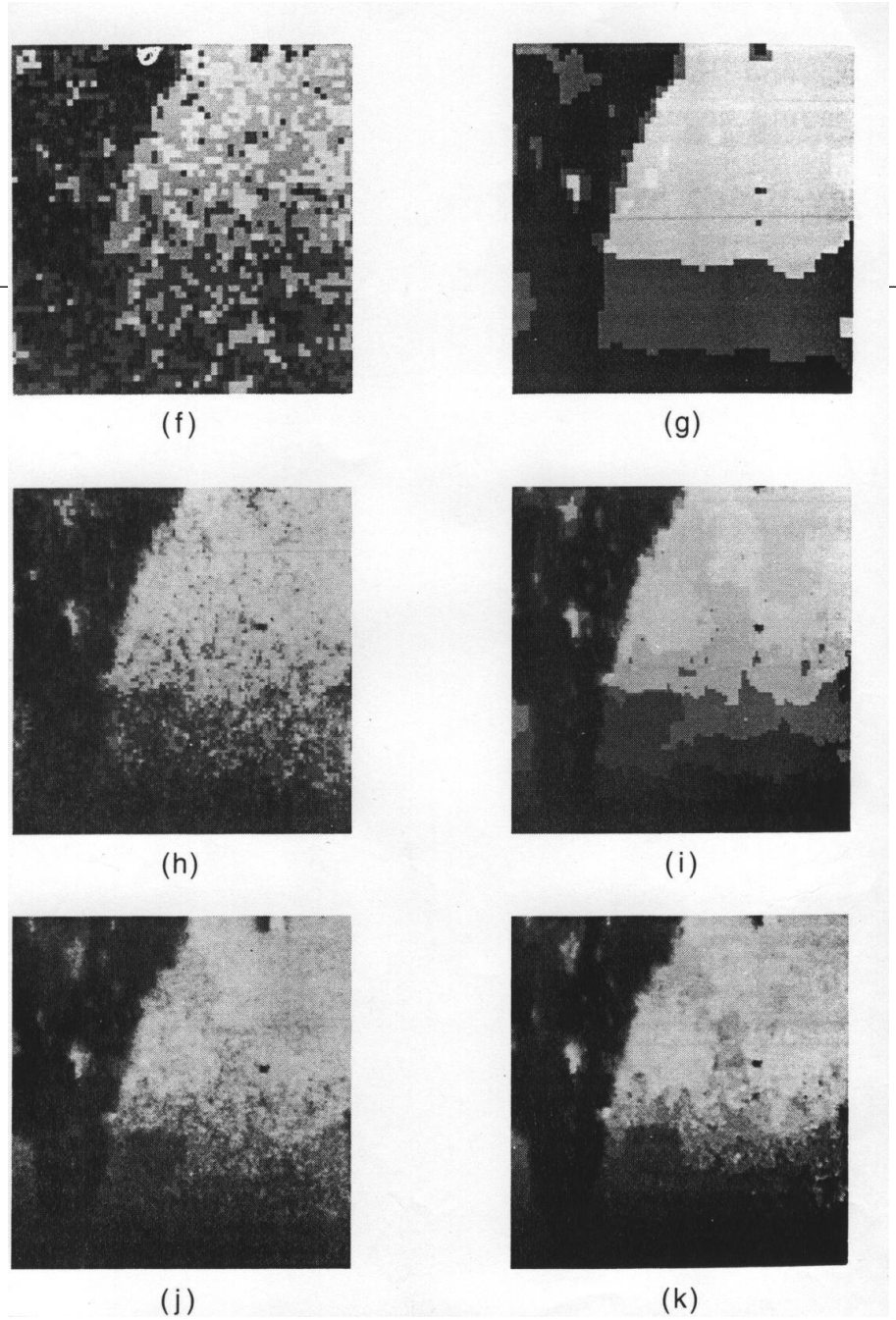


(b)

Shape from Stereo (cont's)

- range image: the darker the nearer, the brighter the farther

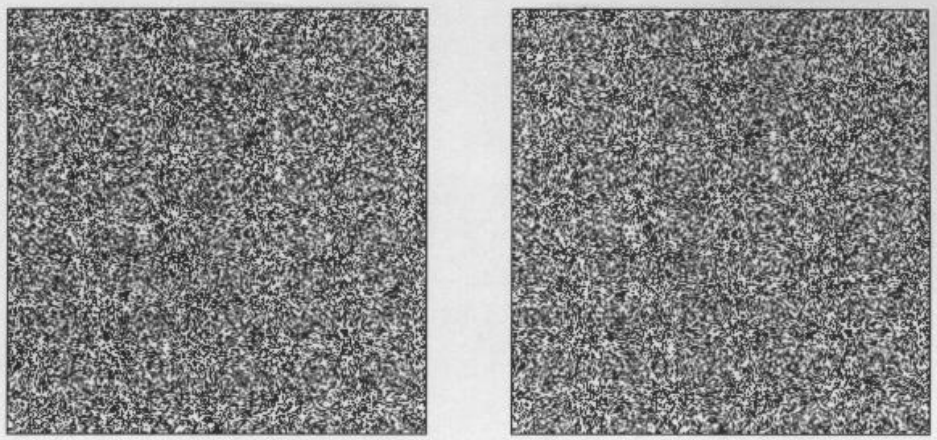

(a)
(b)
(c)
(d)
(e)

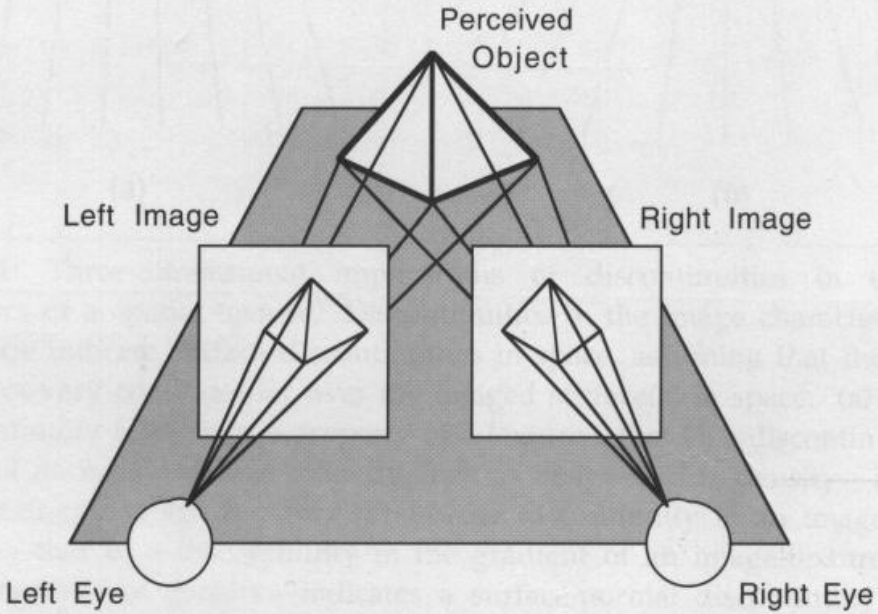

(f)
(g)
(h)
(i)
(j)
(k)

Shape from Stereo (cont's)

- stereo: recovery of 3D scene structure from images of different viewpoints

RDS: random dot stereogram





Shape from Stereo (cont's)

- implication of ambiguous correspondence between image points

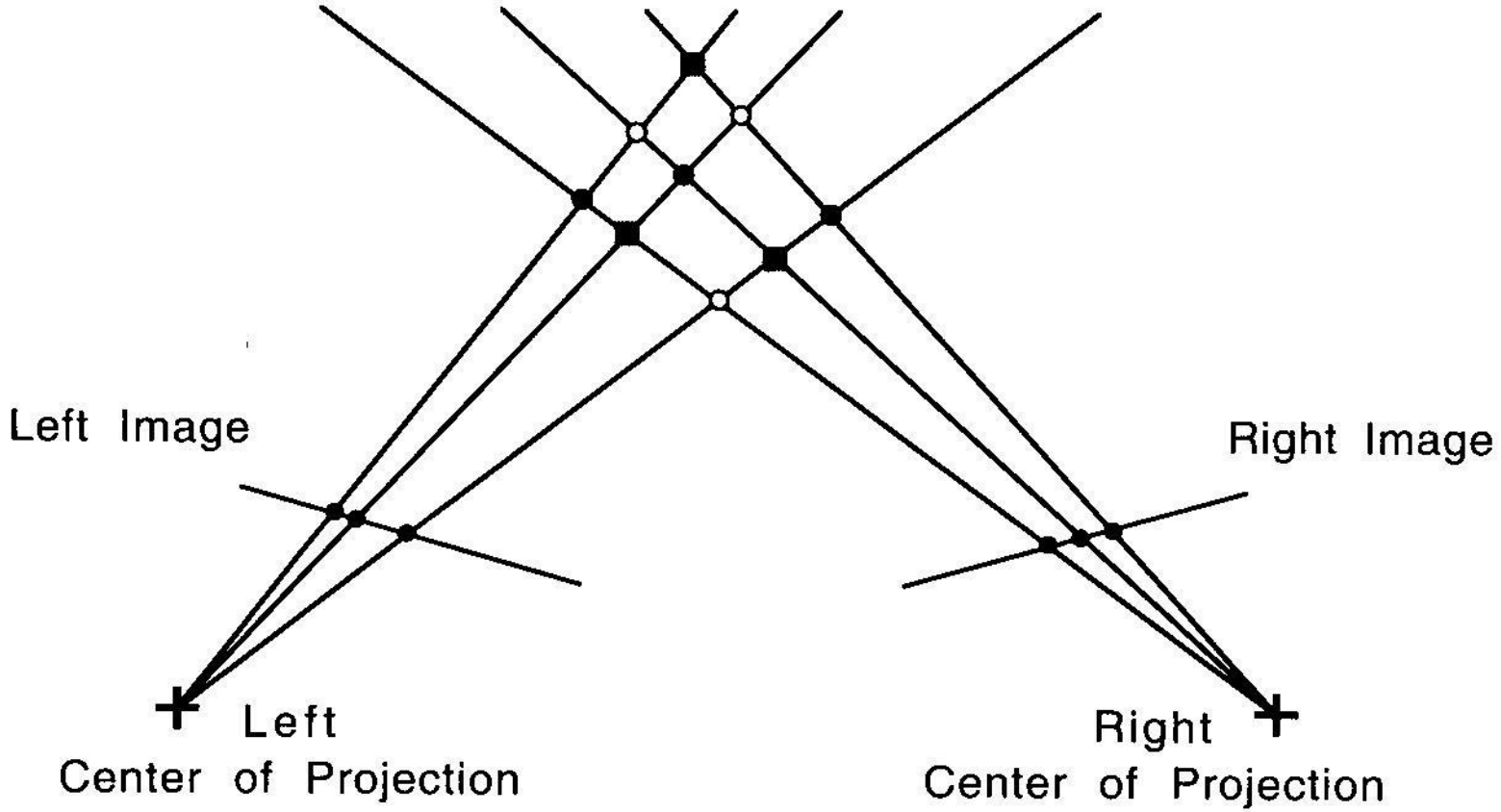
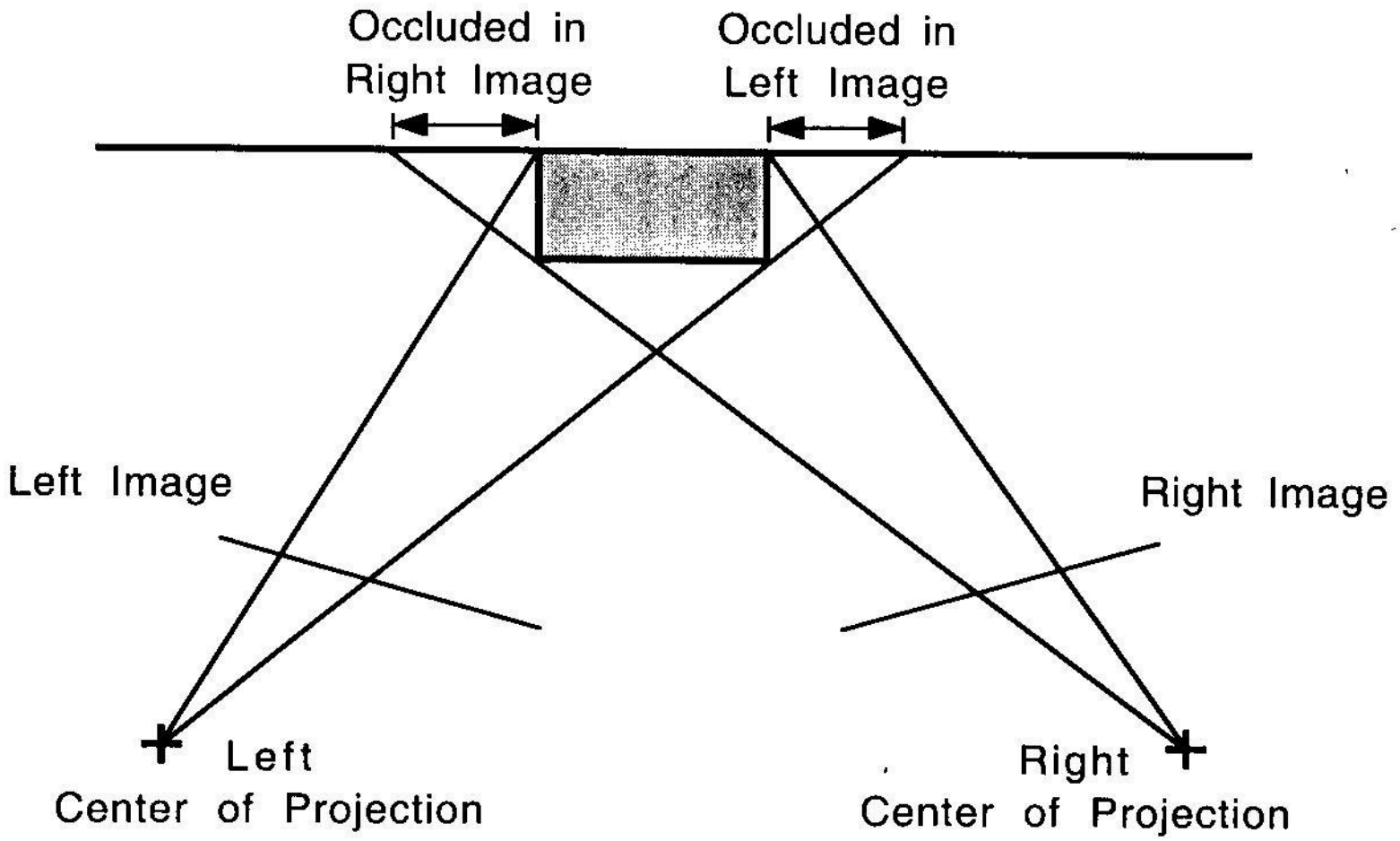


Figure 7.3 The implication of ambiguous correspondence between image points with regard to scene recovery through triangulation. The determination of the three-dimensional locations of scene points through triangulation requires that we establish *correspondence* between individual points in the two images such that each point in a pair of matched points is the image of the same object point. As illustrated, when the correspondence between multiple points in two images is

Shape from Stereo (cont's)

- occlusion as impediment to stereo



e 7.4 Occlusion as an impediment to stereo. Occlusion is a viewpoint-
ıdent phenomenon: Points in the scene that are visible from one viewpoint
not be visible from another viewpoint. The spatial positions of points that are
e from a single viewpoint cannot be recovered through triangulation.

Shape from Stereo (cont's)

- Monotonic-ordering assumption: conjugate image points have same order
- violation of monotonic-ordering assumption

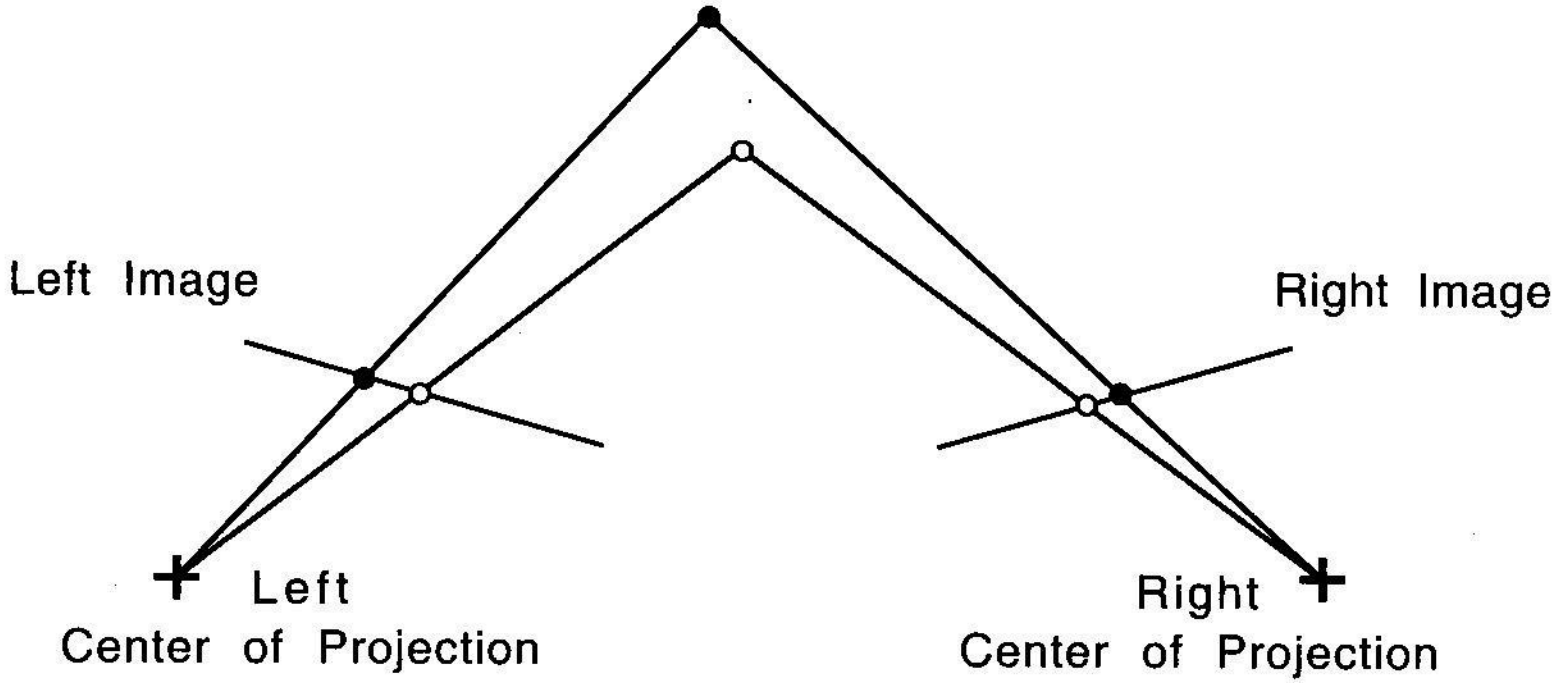


Figure 7.7 Violation of the monotonic-ordering assumption. The *monotonic-order assumption* is this: Conjugate image points along corresponding epipolar lines ha the same order in each image. As illustrated, the monotonic-ordering assumption violated whenever an object point is imaged from either side of another imag object point that lies within the same epipolar plane as the first point.

Shape from Shading

- shading: variation in brightness of surface
- photographs of model with and without makeup

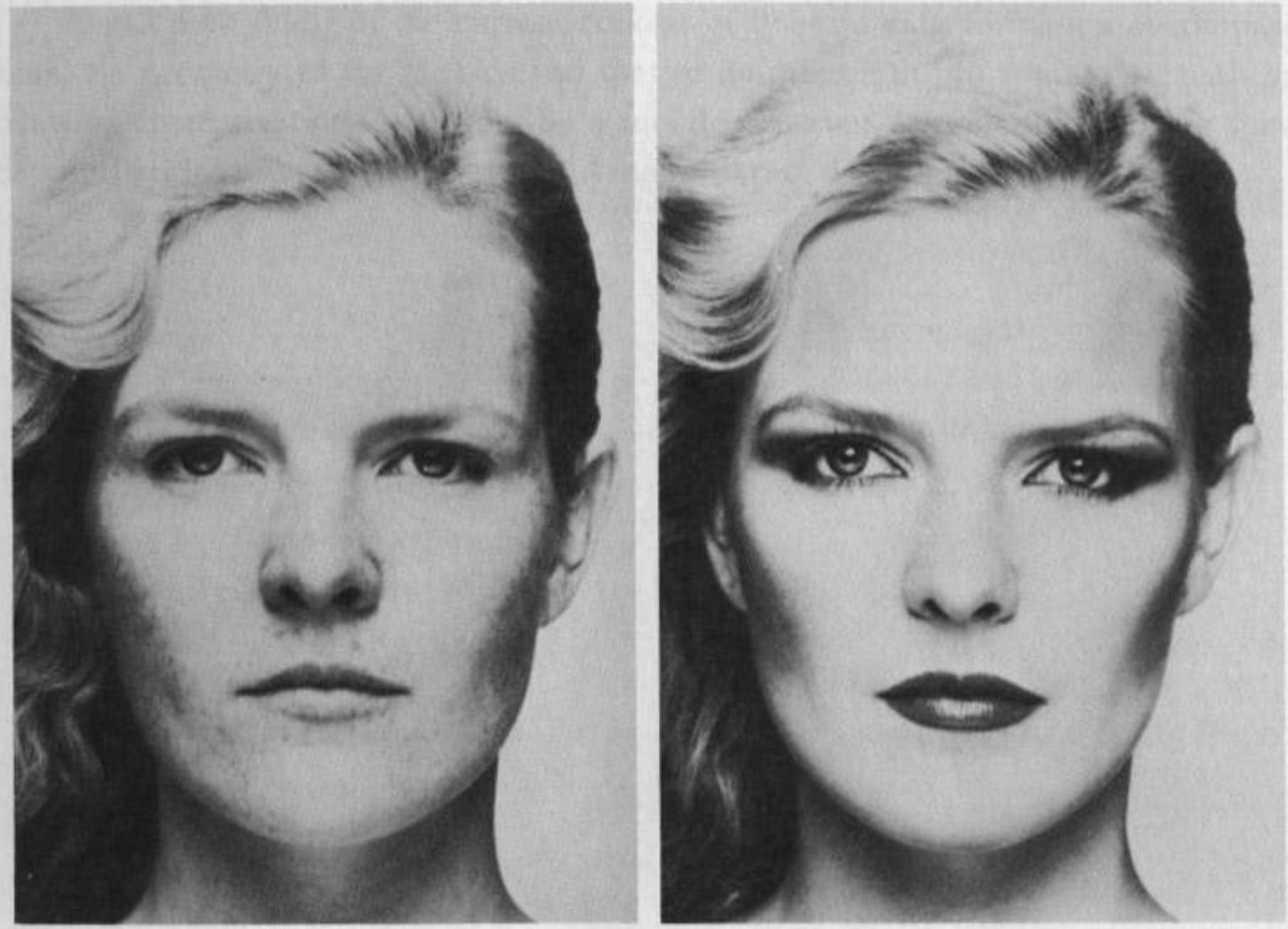


Figure 5.1 Photographs of a model with and without makeup illustrating how the