Space

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INF 143
Space Perception

- Issue: image on retina is 2-D, yet we see the world as 3-D

- Turns out there’s much more than just stereo vision
  - World still looks 3-D with just one eye
  - Rich set of cues for depth
    - Babies recognize much of this as well
Visual Cliff Studies

Eleanor Gibson
Depth Cues

- Monocular Static (pictorial)
  - Linear perspective
  - Aerial perspective
  - Position relative to horizon
  - Texture gradient
  - Size gradient
  - Occlusion
  - Depth of focus
  - Cast shadows
  - Shape-from-shading
  - Depth-from-eye accommodation

- Monocular Dynamic (moving picture)
  - Structure-from-motion (motion parallax)

- Binocular
  - Eye convergence
  - Stereoscopic depth
Linear Perspective

Figure 3. Linear perspective. Parallel lines such as railway lines converge with increasing distance.
Linear Perspective
Linear Perspective
Linear Perspective

- Becomes common in art in the 15th century
- Credited to architect Flippo Brunelleschi, Florence, Italy, in 1425
FIGURE 9-7  An example of linear perspective, in which physically parallel lines seem to converge as they grow more distant. Notice that the lines have been extrapolated to show a vanishing point on the horizon.
Linear Perspective
Linear Perspective

Le Pont de l'Europe, Gustave Caillebotte
Aerial Perspective
Aerial Perspective
Aerial Perspective
Aerial Perspective
Position Relative to Horizon

Figure 5.5.6  Position relative to the horizon. In perspective projection of a 3-D scene, objects on a level plane that are closer to the horizon are perceived as being farther from the observer.
Position Relative to Horizon
Position Relative to Horizon
Texture Gradient
Texture Gradient

Paris Street: A Rainy Day, Gustave Caillebotte
Texture Gradient

Monet
Texture Gradient

Monet
Texture Gradient

Vasarely
Texture Gradient

Vasarely
Size Gradient

FIGURE 9-6  Relative size differences are interpreted as cues for relative distance. Thus, we see a row of puppies that seems to recede in the distance because of their decreasing image size.
Size Gradient
Size Gradient
Size Gradient
Occlusion
Occlusion
Occlusion
Occlusion
Occlusion
Occlusion
Depth of Focus
Cast Shadows

Can Create
A Strong
Sense of Depth

Figure 8.11 Cast shadows can be useful in making data appear to stand out above an opaque plane.
Cast Shadows
Cast Shadows
Shape-from-shading

Figure 8.12: Even with mostly 2D interfaces, subtle shading can make sliders and other widgets look like objects that can be manipulated.
Shape-from-shading
Shape-from-shading
Shape-from-shading
Shape-from-shading

Latest Headlines

Ergonomics In The News:

How occupational therapists can help people to get their day-to-day existence back on track - Getting a
Depth-from-eye accommodation

**Figure 5.2.1** Depth information from lens accommodation. The lens of a human eye changes shape to focus the light from objects at different distances: thin for objects far away and thick for ones nearby.
Motion Parallax

Figure 8.13 Three different kinds of structure-from-motion information. (a) The velocity gradient that results when the viewer is looking sideways out of a moving vehicle. (b) The velocity field that results when the viewer is moving forward through the environment. (c) The kinetic depth information that results when a rotating rigid object is projected onto a screen.
Motion Parallax

Figure 5.4.2 Motion gradients. Gibson discussed patterns of relative motion produced by a moving observer. (A) The optic flow created by an observer moving leftward (large arrow) while fixating the point in the middle of the line. (B) The optical expansion pattern that results from an observer moving toward a fixation point straight ahead, as in walking toward a wall.
Figure 5.2.2 Depth information from eye convergence. The angle of convergence between the two eyes ($a$) varies with the distance to the object they fixate: smaller angles for objects far away ($a_2$) and larger angles for objects nearby ($a_1$).
Stereoscopic depth

Figure 8.15 A simple stereo display. Different images for the two eyes are shown on the left. On the right, a top-down view shows how the brain interprets this display. The vertical lines $a$ and $b$ in the right-eye image are perceptually fused with $c$ and $d$, respectively, in the left-eye image.
Binocular Disparity

Figure 5.3.6 Binocular disparity and stereograms. If the two images in part A are stereoscopically fused with crossed convergence (see text for instructions), the circle and square will appear above the page as indicated in part B. If the two images in part C are cross-fused, the circle and square will appear behind the page, as indicated in part D.
Random Dot Stereogram

**Figure 5.3.8** A random dot stereogram. These two images are derived from a single array of randomly placed squares by laterally displacing a region of them as described in the text. When they are viewed with crossed disparity (by crossing the eyes) so that the right eye’s view of the left image is combined with the left eye’s view of the right image, a square will be perceived to float above the page. (See pages 210–211 for instructions on fusing stereograms.)
Figure 5.3.9 A random dot stereogram of a spiral surface. If these two images are fused with crossed convergence (see text on pages 210–211 for instructions), they can be perceived as a spiral ramp coming out of the page toward your face. This perception arises from the small lateral displacements of thousands of tiny dots. (From Julesz, 1971.)
Figure 5.3.7  Flowcharts for two theories of stereopsis.  (A) The shape-first theory assumes that images in the two eyes are matched by comparing the results of two separate shape analyses.  (B) The stereopsis-first theory assumes that stereopsis occurs before shape analysis. Perception of random dot stereograms supports the stereopsis-first theory (part B).
3D television
3D television
Depth Illusions
Depth Illusions
Depth Illusions
Depth Illusions
Depth Illusions

M.C. Escher
Depth Illusions

M.C. Escher
Perspective Wall
Perspective Wall
Cone Tree
Cone Tree
Cone Tree
Cone Tree
Cone Tree
Data Mountain
Data Mountain
Figure 4-3: Decision Support showing multiple organizational devices.