Seeing Depth
The Cue Approach

- Monocular/Pictorial
  - Cues that are available in the 2D image

Occlusion

Height in the Field of View

Atmospheric Perspective

Linear Perspective

Linear Perspective & Texture
Size and Distance

Emmert’s Law

\[ S_p = C(S_r \times P_p) \]

where

- \( S_p \) = perceived size
- \( S_r \) = retinal size
- \( P_p \) = perceived distance

Ames Room

Shading and more...
Seeing Depth
The Cue Approach

- Binocular
  - stereopsis
    - disparity
  - oculomotor cues
    - Muscle proprioception

Perceiving Objects and Forms

- Task overview and history
  - examples, dogs/horses

- Gestalt Approach
  - Principles of perceptual organization
  - Figure ground separation

- Perceptual Processing Theories
  - Triesman - Feature Integration Theory
  - Marr - Generalized Cones
  - Biederman - Recognition by Components
  - Bülthoff & Edelman & Poggio - Image-based interpolation
Task and Historical Perspective

- Surface perception
  - a complete 3D representation or map of scene - motion, stereo etc.
  - segment into “figure” and “ground”

- Segment/parse into objects
  - Which points in map belong to same objects?

- Recognize and identify objects
  - represent, remember and match to memory

- Scene perception
  - conglomerations of objects
  - layout

Performance Factors

- knowledge and experience
- principles of perceptual organization
- attention
- expectations

Laws of perceptual organization

- Pragnanz - good figure
  - Stimuli should be interpreted so that the resulting form is ASAP
- Similarity
  - Similar shapes, orientations, colors should be grouped together
- Proximity
  - Close things should be grouped together
- Common fate
  - Motion in the same direction should be grouped together
- Meaningfulness and familiarity
  - Groups should look familiar

- Good figure
  - form asap

- Similarity
  - group elements that are similar together
Proximity & Similarity

group elements that are proximal

weaker grouping principles—group parallel and symmetric elements together

Common fate:
- group elements moving in the same direction together

Figure-ground Heuristics
- Figure is more “thing-like” and memorable
- Figure is further front
- Figure “owns” the contour
- Ground is “unformed”

Determinants of F-G separation
- symmetry - figures are often symmetric
- convexity - figures bulge out
- area - figures usually smaller
- orientation - horizontal and vertical
- meaning - figures have meaning (can sometimes be recognized)

Problem - quantifying these rules …..Modern Gestaltists

Quantify - perceptual
- What stimulus properties are responsible for grouping?
- How does grouping affect access of information from displays?

Quantify - visual cognitive - objects
- Treisman (80’s)
  - Preattentive and attentive processes
- Marr (82)
  - Represent in object-centered coordinates - 3D representation
- Biederman (86)
  - Can’t really do it...but can approximate it with intelligent image analysis
- Bülthoff, Edelman, Poggio (90’s)
  - Can’t do this at all - and you don’t really need to
• Treisman & Gelade (82) - feature integration theory

I. Preattentive processing

• primitives, features
  – "words in the language of vision"
  – Unbound to location

• tests of preattentive processing
  – "pop-out" for "features"
  – visual search for features (color, etc)
    » parallel with number of distracting items
    » independent access
  – Illusory conjunctions
    » red triangle - blue square - green circle

II. Focused Attention

• Attention
  – "glue" with which features are bound into objects
  – bound to location
  – Objects = conjunctions of features

• tests of attentive processing
  – No "pop-out"
  – visual search for conjunctions of features red square
    » serial with number of distracting items (RS RT)
    » Co-dependent access

Object and Shape Recognition Theories

• Direct analysis of shapes
  – Problems
    • Viewing angle
    • Photometric problems - illumination, viewpoint, shadows, highlights
    • Object setting - isolation, occlusion
    • Rigid, non-rigid - animated

• Shape invariants
  – Properties of shape common to all views
  – Feature list that specifies object
    • Good - some success in limited situations
    • Bad - not generally applicable

Object and Shape Recognition Theories (continued)

• Structural description
  • Find parts
  • Identify parts
  • Describe structural relations among the parts
    – examples - Bottom-up Approaches
      • Feature hierarchies Pandemonium model (Selfridge,50)
      • Generalized Comes as Parts - (Marr, 82)
        – Raw primal sketch
        – 2D/3D sketch
        – 3D object centered representations
Object and Shape Recognition Theories (continued)

- Recognition by components (Biederman, 86)
  - Geons (about 50)
  - Least changeable with viewpoint
  - Maximize image features that generalize
  - Psychological evidence
  - Accidental and non-accidental views

Object and Shape Recognition Theories (continued)

- Image-based models (Poggio & Edelman, 91)
  - 2D image analysis
  - Store multiple views
  - Interpolate in image space
  - Special or canonical views

- Alignment models (Ullman 90’s)
  - Within a category - solve correspondence
  - Align to a “special” view
  - Transform from 2D to 3D
  - Match