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

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
Seeing Depth
The Cue Approach

• Binocular
  – stereopsis
    • disparity
  – oculomotor cues
    • Muscle proprioception

Disparity = \theta_1 - \theta_2

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
  – Bulthoff & 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/parsing into objects
  - Which points in map belong to same objects?

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

- Scene perception
  - conglomerations of objects
  - layout

Performance Factors

- knowledge and experience
- principles of perceptual organization
- attention
- expectations
- Gestalt psychology
- Max Wertheimer (1912)
- whole > sum of parts

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

1. **•** weaker grouping principles—group parallel and symmetric elements together

2. **•** 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
  • Bulthoff, Edelman, Poggio (90’s)
    • Can’t do this at all - and you don’t really need to

• Treisman & Gelade (82) - feature integration theory

• 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 locations
    – 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 (Selridge,59)
    • Generalized Cone as Parts - (Marr, 82)
      – Raw primal sketch
      – 21/2 D 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 (continued)
  - Interpolation 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