PERCEIVING OBJECTS

Visual Perception
Different Approaches

- **Physiological Approach**
  - Molecules → Neurons → Circuits & Brain Areas → Brain

- **Psychophysical Approach**
  - Individual Features → Groups of Features → Objects → Scenes
Gestalt Approach

- Gestalt psychology
  - Structuralism: Perception is created by combining elements called *sensation*

- But this cannot explain
  - Apparent Movement
  - Illusory Contours
Apparent Movement

(a) Flash line on left
(b) 50 ms of darkness
(c) Flash line on right
(d) Perception: movement from left to right
Illusory Contours
Whole is different from the sum of its parts
Basic Philosophy

- The whole is different than the sum of its parts
- Six principles defining perceptual organization
  - How do we combine components to perceive the whole?
  - Is their any basic rules that we use?
Gestalt Principles of Perceptual Organization

- Law of Simplicity
- Law of Similarity
- Law of Good Continuation
- Law of Proximity
- Law of Common Fate
- Law of Familiarity
Law of Simplicity

- Every stimulus pattern is seen in a way that is as simple as possible.
Law of Similarity

- Similar things appear to be grouped together

Shape

(a)  (b)

Orientation

Lightness

Aditi Majumder, UCI
Points that when connected are seen as straight or smoothly curving lines tend to be seen as belonging together, and the lines tend to be seen in such a way that they follow the smoothest path.
Law of Good Continuation

- Points that when connected are seen as straight or smoothly curving lines tend to be seen as belonging together, and the lines tend to be seen in such a way that they follow the smoothest path.
Law of Proximity or Nearness

- Things close together appear to be grouped together
- Overcomes law of similarity in this example
Law of Common Fate

- Objects moving in the same direction appear to be grouped together
Law of Familiarity

- Objects appear to be grouped if the groups appear to be familiar or meaningful.
Heuristic and not Algorithm

Where does the heuristics come from?
Palmer-Irvine Principles of Perceptual Organization

- Common Region
- Element Connectivity
- Synchrony
Quantitative Measure of Grouping Effects

- Repetition Discrimination Task
Perceptual Segregation

- **Gestalt Theory**
- **Reversible figure ground**
  - Figure more object like
  - Figure seen as being in front of ground
  - Ground is uniform region behind figure
  - Separating contours appear to belong to figure
Factors Determining Figure and Ground

- Figure
  - Symmetry
  - Smaller Areas
  - Horizontal or Vertical
Factors Determining Figure and Ground

- Figure
  - Familiarity
Modern Research

- Role of Contours
  - Likeliness of Occurrence
- When does segregation occur?
  - Popular belief
    - First segregation, then recognition
  - Later proved
    - Recognition and segregation may happen in parallel
Perceiving Objects

Physiological Approach

Molecules → Neurons → Circuits & Brain Areas → Brain

Psychophysical Approach

Individual Features → Groups of Features → Objects → Scenes
How Objects are Constructed?

- Marr’s computational Model
- Feature Integration Theory (FIT)
- Recognition-by-Components Theory (RBC)
Marr’s Theory of Object Construction

- Computational Approach

Object’s image on the retina → Identify edges and primitives → Groups primitives and processes → Perceived 3-D object
Marr’s Theory

- Computational Approach
  - Creation of *raw primal sketch*
    - Analysis of light and dark region of retinal image
    - Using natural constraints
      - E.g. Illumination edge vs. geometric edge
    - Do not see this
  - Processed to develop a 2.5D sketch
Feature Integration Theory (FIT)

- **Preattentive Stage**
  - Detects features
- **Focused Attention Stage**
  - Features are combined to perceive the object
FIT: Preattentive Stage

- Pop-out boundary for detecting features
  - Different Orientation
  - Different Value
FIT: Preattentive Stage

- Visual Search Detection Time
  - Constant with increase in number of distractors if target has pop-out features
  - Increases with increase in number of distractors if target has no pop-out features
    - Have to scan each distractor and eliminate

Similar to Salience
FIT: What makes things pop out?

- Curvature
- Tilt
- Line ends
- Movements
- Color
- Brightness
- Direction of Illumination
FIT : Preattentive Stage

- Independent features
- No association with objects
- Same observation from physiology
FIT : Focused Attention Stage

- Attention is essential for combining features
- Same result from physiology
Recognition-by-Components (RBC)

- Volumetric Primitives
  - Geons
- Principle of componential recovery
Properties of Geons

- View invariance
- Discriminability
- Resistance to visual noise

Cannot be mathematically enforced. Not very formal. Limitation of many psychophysical model. No hard quantification.
RBC theory

- Can identify objects based on a few basic shapes
- Cannot help us detect the finer details which causes difference
Comprehensive Model

- Image Based Stage
- Surface Based Stage
- Object Based Stage
- Category Based Stage
Image Based Stage

- Retinal Image
- Local feature detection
Image Based Stage

- Retinal Image
- Local feature detection
  - Edges, Corners, blobs
  - Raw primal sketch
- Global relationship between them
  - Full primal sketch
  - Difficult

Similarity with Marr’s Primal Sketch
Image Based Stage

- **Primitives**
  - 2D structure of image intensities
    - Features like edges, blobs, corners etc

- **Geometry**
  - Two dimensional

- **Reference Frame**
  - Retinal
Surface Based Stage

- Find intrinsic property of surfaces in the real world
- Surfaces in 3D world as opposed to 2D primitives
- Visible surfaces from which light reflects to our eye
- *Intrinsic Images*
Surface Based Stage

- Represented by 2D planar elements in 3D
  - 3D surface can be represented by infinite 2D planar elements
  - Properties
    - Distance from viewer
    - Slant
    - Shading (as color or texture)
  - Like a 2D rubber sheet wrapped on the face of the visible surfaces.

Similarity with Marr’s 2.5D representation
Surface Based Stage

- **Primitives**
  - 2D planes embedded in 3D

- **Geometry**
  - Three dimensional

- **Reference Frame**
  - Viewer dependent
Object Based Stage

- We have some 3D definition
  - Otherwise, surprised when hidden surfaces got exposed

- Two types of representation
  - 2D patched in 3D
  - 3D volume elements
    - Hierarchical

*Similarity with Recognition by Components*
Object Based Stage

- **Primitives**
  - 2D planes embedded in 3D
  - Volumes

- **Geometry**
  - Three dimensional

- **Reference Frame**
  - Object dependent
Category Based Stage

- Categorization
- Identification
- Cognitive Science
- Deals with knowledge in perception
- How it helps us survive
- What about more frames? The temporal domain is not explored that much
Relationship to Graphics

- **OpenGL triangular rendering**
  - 2D triangle mesh embedded in 3D
  - Triangle is smallest planar 2D elements

- **Volume Rendering**
  - Uses volumes as primitives

- **Image based Rendering**
  - Depth Images analogous to surface based representation
  - That is why a view dependent rendering scheme is adopted
  - Since no object based information, difficulty in handling occlusion
Role of Intelligence in Object Perception

- Ambiguous Stimulus
  - Inverse Projection Problem
Role of Intelligence in Object Perception

- Ambiguous Stimulus
  - Inverse Projection Problem
- Objects not separated
- Occlusion
- Ambiguity in lightness
Intelligence Heuristics

- Occlusion
- Light from above