Objects and Scenes

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April 29, 2008
Visual Interpolation
  Visual Completion
  Illusory Contours
  Perceived Transparency

Multistability
  Network Model
  Neural Fatigue

Constancy and Illusions
  Shape
  Orientation
  Position

Perceptual Adaptation

Parts
  Segmentation
  Global & Local Processing
Visual Interpolation

What is it all about?

How to infer the nature of **hidden part** from visible ones.
Visual Completion

Illusory Contour

Perceived Transparency
Visual Completion

Automatically perceives **partly occluded** surface as **complete**
Visual Completion

Automatically perceives partly occluded surface as complete
Visual Completion

Automatically perceives partly occluded surface as complete
Multiple perceptions are possible
But there’s usually single dominant one
How might it happen?
Multiple perceptions are possible
But there’s usually single dominant one
How might it happen?
- figural familiarity
- figural simplicity
- ecological constraint
Figural Familiarity Theory

complete occluded figures according to most frequently encountered shape that is compatible with the visible part
Pros and Cons

- **Problem**: we can complete novel shape
- The theory is still effective, though.
Figural Simplicity Theory

- produce the "simplest" figures
Figural Simplicity Theory

- produce the "simplest" figures
- **Problem**: how to measure "simplicity"
Outline

Visual Interpolation
Visual Completion
Illusory Contours
Perceived Transparency
Multistability
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Perceptual Adaptation
Parts
Outline
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Suppose

(i) simplicity $\Rightarrow$ number of axes of symmetry
Suppose

(i) simplicity $\Rightarrow$ number of axes of symmetry

(ii) simplicity $\Rightarrow$ number of sides
Ecological Constraint Theory

- based on ecological evidence of occluded contours
- e.g. T-junction
- relatability theory
Relatability Theory

Example

1. edge discontinuities are necessary
2. discontinuities are “relatable”
2.1 intersect at an angle $\leq 90^\circ$
2.2 smoothly connected
3. form an enclosed area
4. infer position in depth
Relatability Theory

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Illusory Contours

Perceiving **contours** that **do not exist** in stimulus image
Illusory contours generally come with visual completion
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Illusory Contours and Visual Completion

Alternative perception with same underlying process of visual system
Illusory Contours and Visual Completion

Alternative perception with same underlying process of visual system
Illusory Contours and Visual Completion

Alternative perception with same underlying process of visual system
Perceived Transparency

perception as being viewed through a closer translucent object
must satisfy two conditions

1. spatial condition
   (i) immersed in single region (B)
   (ii) unity destroyed (C)
   (iii) unity weakened (D)

2. color condition (E)
Multistability

- more than one perception
- spontaneously alternate among two or more perception
Necker cube
Q1:

Why only one interpretation at any moment?
Assumption: different patterns of neural activity → different interpretations
Cooperation & Competition

- Cooperation:
  - Mutual excitatory links
  - Connecting the same subnetwork

- Competition:
  - Mutual inhibitory links
  - Connecting different subnetworks
  - Only one subnetwork is active at any moment
Cooperation & Competition

- Cooperation
  - mutual excitatory links
  - connecting same subnetwork
Cooperation & Competition

- Cooperation
  - mutual excitatory links
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- Competition
  - mutual inhibitory links
  - connecting different subnetwork
Cooperation & Competition

- Cooperation
  - mutual excitatory links
  - connecting same subnetwork

- Competition
  - mutual inhibitory links
  - connecting different subnetwork

- only one subnetwork is active at any moment
Q2:

Why the **alternation** happen?
Neural Fatigue Theory

Assumption: Neurons are getting tired

- Due to depletion of biochemical resources needed to fire
- cause alternating interpretation when combined with mutual inhibition
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Visual Interpolation
Multistability
Network Model
Neural Fatigue
Constancy and Illusions
Perceptual Adaptation
Parts
Other effects

Fatigue Theory is Not perfect
- Eye Fixation
- Role of Instructions
Perceptual Constancy and Illusions

- Shape
- Orientation
- Position
Shape Constancy

Perceive as constant despite changes in viewing perspective

Figure: Doors at different slant look the same as door in the frontal plane.
How might we expect changes in perspective to affect shape constancy?
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Depth information
How might we expect changes in perspective to affect shape constancy?

Depth information

- **Accurate depth information from absolute sources**
  - accommodation and/or convergence
  - *shape* and *size* can be completely recovered
How might we expect changes in perspective to affect shape constancy?

Depth information

- Accurate depth information from absolute sources
  - accommodation and/or convergence
  - shape and size can be completely recovered
- Accurate relative depth from quantitative sources
  - binocular disparity, motion parallax, or many of the metric sources of perspective information
  - shape will be recoverable but not size
How might we expect changes in perspective to affect shape constancy?

Depth information

- **Accurate depth information from absolute sources**
  - accommodation and/or convergence
  - shape and size can be completely recovered
- **Accurate relative depth from quantitative sources**
  - binocular disparity, motion parallax, or many of the metric sources of perspective information
  - shape will be recoverable but not size
- **Only qualitative depth information**
  - edge interpretation
  - neither precise shape nor size can be unambiguously recovered
Two-Dimensional Figures

- When objects are close enough to provide accurate depth information, shape constancy is quite good.
- Shape constancy declines as the degree of slant increases.
- Strong bias toward perceiving symmetrical shapes and familiar shapes.

**Figure:** Perspective views of a square on a wide variety of different perspectives.
Three-Dimensional Objects

Irvin Rock and his colleagues

- Observers have surprisingly poor shape constancy
- Perception of shape is strongly influenced by the qualitative changes in the retinally projected shape
- Under distant viewing conditions, shape constancy should be worse than in near viewing conditions
Three-Dimensional Objects

Everyday experience

- We see objects from many different perspectives and manage to recognize them reasonably well despite the variations in appearance.
Three-Dimensional Objects

Everyday experience

- We see objects from many different perspectives and manage to recognize them reasonably well despite the variations in appearance.

Possibilities

- Continuously moving from one view to another.
- Correlated with object’s identity.
- Axes of symmetry or elongation.
Shape Illusions

The ellipse/circle illusion
Shape Illusions

The ellipse/circle illusion
Shape Illusions

The ellipse/circle illusion
Orientation Constancy

Objects in the environment appear to retain their original orientations.

Figure: The perceived orientation of objects in the environment does not appear to change when we tilt our heads, even though their retinal images rotate in the opposite direction.
Orientation Constancy

- $O_{object}$ - object’s environmental orientation
- $O_{image}$ - object’s image orientation with respect to the long axis of the head
- $O_{head}$ - observer’s head orientation with respect to gravity

$$O_{object} = O_{image} + O_{head}$$
Proprioceptive System

The primary source of information about gravitational orientation of the head

Figure 2: The Vestibular System - semicircular canals and otolith organs
Orientation Illusions

Frames of Reference - The Tilted Room Illusion
Orientation Illusions

Frames of Reference - The Tilted Room Illusion

http://www.youtube.com/watch?v=FngLFzS-Sa0
Orientation Illusions

Frames of Reference - The Tilted Room Illusion
Orientation Illusions

The rod-and-frame effect
Orientation Illusions

The rod-and-frame effect

[Image of a rod-and-frame effect]
Orientation Illusions

The rod-and-frame effect
Orientation Illusions

Geometric Illusions - The Zollner Illusion
Orientation Illusions

Geometric Illusions - The Zollner Illusion
Orientation Illusions

Geometric Illusions - Contrast Illusion
Position Constancy

The visual systems ability to perceive **unmoving objects** as **stationary**
Egocentric position

- Objects’ positions relative to the observer’s body
- Polar coordinates
  - Radial direction from observer to object
  - Distance from observer to object

Figure 4. The cyclopean eye is used to determine the direction of point A and point B. Point A stimulating the temporal retina of right eye and the nasal retina of the left eye, that is, stimulates a retinal point to the right of the fovea.
Perception of Direction

- $P_{object}$ - the environmental position of the object with respect to egocentric straight ahead
- $P_{image}$ - the image position of the object projection with respect to the center of the retina
- $P_{eye}$ - the position of the eye with respect to the egocentric straight ahead

$$P_{object} = P_{image} + P_{eye}$$
Position Constancy

The visual systems ability to perceive **unmoving objects** as **stationary**
Position Constancy

A change in the position relative to its previous position

- $\Delta P_{\text{object}}$ - the change in environment direction of an object
- $\Delta P_{\text{image}}$ - the change in its image position on the retinal
- $\Delta P_{\text{eye}}$ - the change in direction of the eye

$$\Delta P_{\text{object}} = \Delta P_{\text{image}} + \Delta P_{\text{eye}}$$
Position Constancy

\[ \text{Eye Movement} + \text{Image Displacement} = \text{Object Displacement} \]

Change in eye position + Change in image position = Change in object position

\[ \Delta P_{\text{eye}} + \Delta P_{\text{image}} = \Delta P_{\text{object}} \]

Rightward eye movement, Stationary object

Eye tracks object moving rightward

Eye stationary; Object moving rightward
Indirect Theories of Position Constancy
Direct Theories of Position Constancy

Gibson (1966)
Based entirely on the structure of optical flow
The visual system simply subtracts out any common motion vector in the flow field
Position Illusions

Move the eye passively by an external force
The whole environment appear to move
Perceptual Adaptation

- We have roughly accurate perception of object properties such as size, shape, position, and orientation under a wide range of normal viewing conditions.
- Computed from corresponding properties of their retinal projections plus a variety of other relevant factors (e.g., distance, head orientation).
Perceptual Adaptation

Changing in conditions of viewing by optical transformations

- e.g., shifted, inverted, rotated, left-right reversals, enlargements and reductions
Perceptual Adaptation

Pointing without prism

Before Adaptation
Perceptual Adaptation

Pointing with prism

Before Adaptation
Perceptual Adaptation

Pointing with prism
Perceptual Adaptation

Pointing without prism

After Adaptation
Perceptual Adaptation

Prism shifted the image of the visible world to the side

- Miss object by the prism’s angle of displacement
- Caused by discrepancy between visually perceived position and actual position
- Practice reaching objects reduce in motor error
- Negative aftereffect
Perceptual Adaptation

What would the world look like if retinal images were somehow transformed so that they were not inverted?
Perceptual Adaptation

Viewing the world through a prism that uninverted the retinal image
Perceptual Adaptation

Effects of **uninverting** the retinal image

- Initially the world looked completely **upside-down**
- Severe difficulties at first
- Several days, able to do daily activities
- No negative aftereffect
Adaptation in active versus passive observers

- Actively walked versus passively on a wheel cart
- Active observers adapted more fully transforming effects
- Controlling play important role in adaptation
Parts
Parts

- We perceive size, shape, orientation and parts
- Linguistic evidence
- Phenomenological evidence
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How does visual system determine what the parts are?

- shape primitive
- boundary rules
Shape Primitives

Define atomic shapes

e.g. Generalized cylinders
Problems

1. contextual effect
2. part/whole hierarchy
Boundary Rules

Define general rules about boundaries between parts

- maximal concavities
- concave discontinuities
Global & Local Processing

What comes first, Whole or Parts?
Global objects Proceed Local parts

**Diagram:**

- **LOCAL LEVEL**
  - S
  - H
- **GLOBAL LEVEL**
  - S
  - H

- **Consistent**
  - SSSSSS
  - SSSSSS
  - Consistent
- **Conflicting**
  - HHHHHH
  - HHHHHH
  - Conflicting
Results

1. Global precedence
2. Global-to-local interference
3. Lack of local-to-global interference
Processing of Global/Local information

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End
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Appendix

A

B

C

Relatable Edges

D

E

F

Unrelatable Edges