The Art and Science of Depiction

Vision Solves Problems

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Plan

• Vision as an cognitive process
• Computational theory of vision
• Constancy, invariants
Distal vs. proximal stimulus

- Distal stimulus: reality
- Proximal stimulus: retinal image
Vision as an inverse problem

• The distal stimulus is projected into a proximal stimulus

proximal stimulus (2D)  Distal stimulus (3D)
Vision as an inverse problem

• The distal stimulus is projected into a proximal stimulus
• How can we inverse this projection?

proximal stimulus (2D)  Distal stimulus (3D)
Unconscious inference (Helmholtz)

- Our vision system solves a problem
- Under-constrained problem
  - A visible point $A'$ can correspond to an infinity of 3D points ($A_1, A_2, A, A_3...$)
Unconscious inference (Helmholtz)

- Our vision system solves a problem
- Under-constrained problem
- Assumptions on the scene
The Ames room

- Invalid assumption
- Wrong conclusions
Ames chair

- Different scenes
- Same projection
- We assume it is a chair
Patrick Hughes

- Perspective painting on the inverse geometry
The paradox of vision

- Available information: proximal stimulus
- Conscious information: distal stimulus
The paradox of Pictures

• Distal vs. proximal
• Available information: proximal stimulus
• Conscious information: distal stimulus

proximal stimulus (2D)  Distal stimulus (2D/3D)
Pictures and inverse problem

• Can
  – Simplify analysis
  – Be a puzzle
Plan

- Vision as an cognitive process
- Computational theory of vision
- Constancy, invariants
Vision as information processing

- Input: retinal image
- Output: 3D layout, object recognition, etc.
Computational theory of vision

- Marr’s stages (extended by Palmer et al.)
- Human and Computer Vision
- Classification of different kinds of processes
- Has proved fruitful in art studies
Computational theory of vision

- Marr’s stages (extended by Palmer et al.)
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Retinal image

- Intensity
Retinal image

- Intensity: hard to comprehend
Retinal image

- Intensity
Image-based (primary sketch)

- Contrast, edge detection
Image-based (primary sketch)

- Contrast, edge detection
- Not so easy

Raw edge detection
Image-based (primary sketch)

- Contrast, edge detection
**Surface-based**

- Visible surfaces, organization
- Distance, orientation

Local orientation
Surface-based

- Visible surfaces, organization
- Distance, orientation

Local orientation
Surface-based

- Visible surfaces, organization
- Distance, orientation

![Diagram of surface-based processing](image)

- Retinal Image
- Image-based Processing
  - Shading
  - Stereo
  - Motion
  - Edges
  - Texture
- Surface-based Processing
**Surface-based**

- Visible surfaces, organization
- Distance, orientation

Local orientation
Object-based

- 3D properties, structure
- Nature of the description highly discussed
Category-based

- Recognition, category, function
Feedback

- Bottom-up and top-bottom

Cup
Scope of the theory

- Computer Vision
- Human Vision
- No direct correspondence in the brain
- Has proved fruitful conceptual tool
Relation to children drawing

• First children draw what they know
  – Object-centered
• Then, what they see
  – View-centered

Age 5

Age 9 (gifted!)
Evolution of children’s drawings

- Asked to draw a table

Class of drawing & average age

- 7.4
- 9.7
- 11.9
- 13.6
- 14.3
- 13.7
What about adults?

- Reproduce two drawings with similar angles
- Wheel:
  - Accuracy $\sim 5^\circ$
- Street:
  - Error: $32^\circ$
Drawing reproduction

- From *Drawing on the right side of the brain*
- Reproduction of Picasso’s *portrait of Stravinsky*

Original | Regular reproduction | Performed upside-down
Relation to pictures

• How we see pictures
• Different classes of pictures for different stages

View-centered
Extrinsic

Object-centered
Intrinsic
Relation to pictures

- Different classes of pictures for different stages
- Not a strict classification

View-centered
  Extrinsic

Object-centered
  Intrinsic
Relation to pictures

- Chinese painting refuse extrinsic, only essential
- No shadow

View-centered
Extrinsic

Object-centered
Intrinsic
Retinal image

• Impressionism
Retinal image

- Impressionism
- Photography
Image-based

• Line Drawing
Intermediate

- View-based
- Cues for surface-based feature extraction are enhanced
  - Depth cues
  - Orientation cues
- No subjective feature (e.g. lighting)
Intermediate

- View-based
- Cues for surface-based feature extraction are enhanced
  - Depth cues
  - Orientation cues
- More subjective feature (lighting)
Higher level

- Primitive art
- Cubism
- Schema
- “What I know”
Higher level

- Primitive art
- Cubism
- Schema
- “What I know”
Higher level

- Primitive art
- Cubism
- Schema
- “What I know”
Higher level

- Primitive art
- Cubism
- Schema
- "What I know"
- Not limited to picture
Expressionism

• “What I feel”
Relation with 2D/3D qualities

- Almost the opposite!
- 3D quality correspond to retinal image
- 2D quality arises from higher-level pictures
- Because of vision paradox
  - Distal is seen when proximal is shown
Relation with 2D/3D qualities

- 3D quality but Retinal image
Relation with 2D/3D qualities

- 2D quality but Higher level
Further reading
Plan

- Vision as an cognitive process
- Computational theory of vision
- Constancy, invariants
Constancy & Invariants

- We see intrinsic properties of objects
- They are “invariant” or “constant”
- Ecological advantage
Visual angle vs. size

- We see cylinders with same size
- Valid most of the time
Visual angle vs. size

- Mirror experiment:
  - Draw your face on a mirror
  - Measure: the drawing is ½ your face
  - However, you see “full size”
Visual angle vs. size

• How do we do that?
  – Distance
  – Familiarity
  – Assumptions

• Here
  – Perspective
  – Position on ground plane
  – Similarity
Brightness vs. lightness

- Brightness: subjective amount of light
- Lightness: how “white”

The white cells in shadow are as dark as the black illuminated cells
Lightness constancy

Intro to Visual Perception
Lightness constancy

- Sargent
- White in light and in shadow
Color constancy

• Chromaticity of light sources vary
• Chromatic adaptation
  – Similar to white balance on camcorder
  – Different films, filters

Objective colors under neon lighting  With chromatic adaptation
Constancy

- Size
- Lightness
- Color
- Position
- Orientation
- Shape
Degree of constancy

- Not always perfect
- Sometimes too much
Degree of size constancy

• The Moon illusion
  – The Moon appears bigger on the horizon
  – Because it looks farther (Emmert’s law)
  – Because references
Degree of color constancy

- Incandescent light looks warmer
- Sodium lighting looks yellowish
- Depends on intensity
Constancy & Pictures

- Estimate size of depicted objects
- Different virtual viewpoints

Figure 4.8. Mean magnitude estimates (log scale) as a function of object size. Viewing distance is a parameter. Data collected for photographs. (○, 75 cm; △, 50 cm; □, 25 cm.)
Constancy & Pictures

• Estimate slant of depicted objects
• Different real viewing angles

FIGURE 4.17. Judged slant in rotated pictures with complete information for picture plane location.
Importance of frame

- Estimate slant of depicted objects
- Different real viewing angles, invisible frame

FIGURE 4.16. Judged slant in rotated pictures with reduced information for location of picture plane.
Constancy & Pictures

- Hybrid constancy with respect to
  - Picture object
  - Depicted scene
Constancy & Pictures

- Hybrid constancy
- Problem
- Richness
Degree of constancy

- Vermeer *Soldier and a Laughing Girl*
- Too good to be true: use of camera obscura
Size constancy failure
Size constancy failure
Size constancy failure
Breaking size constancy for symbol

- Middle-age
- Size = social importance
Size constancy dissonance

• Surrealism (Magritte)
Color constancy and pictures

- Chromatic adaptation with respect to picture object, not with respect to dictated scene
Constancy & architecture

- Palazzo Spada in Rome (by Boromini)
- Short corridor
- Column size decreases
- Appears longer
Constancy & Make Up
Constancy & Lighting
Next session

- Gestalt and picture organization
- Gaze movement and focal point
Assignments

- Piranesi
  - Tutorial 1 to 4

- Reading
  - Art and Illusion, Gombrich
  - Summary 1 to 2 pages
  - 2 Discussion issues

- Feedback, 1 picture
Discussion

- The Man Who Mistook his Wife for a Hat
- The Colorblind Painter
- Oliver Sacks