**Plan**

- Vision as a cognitive process
- Computational theory of vision
- Constancy, invariants

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**Distal vs. proximal stimulus**

- Distal stimulus: reality
- Proximal stimulus: retinal image

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**Vision as an inverse problem**

- The distal stimulus is projected into a proximal stimulus

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**Vision as an inverse problem**

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

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**Unconscious inference (Helmholtz)**

- Our vision system solves a problem
- Under-constrained problem
  - A visible point A' can correspond to an infinity of 3D points (A1, A2, A, A3…)

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### 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
**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

**Retinal image**
- Intensity
Retinal image

- Intensity: hard to comprehend

Image-based (primary sketch)

- Contrast, edge detection

Surface-based

- Visible surfaces, organization
- Distance, orientation
**Surface-based**

- Visible surfaces, organization
- Distance, orientation

**Object-based**

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

**Category-based**

- Recognition, category, function

**Feedback**

- Bottom-up and top-down
**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

**Relation to pictures**
- How we see pictures
- Different classes of pictures for different stages

**Evolution of children’s drawings**
- Asked to draw a table

<table>
<thead>
<tr>
<th>Class of drawing &amp; average age</th>
<th>Child’s view</th>
<th>Age 5</th>
<th>Age 9 (gifted!)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child’s view</td>
<td>7.4</td>
<td>11.9</td>
<td>14.3</td>
</tr>
<tr>
<td></td>
<td>9.7</td>
<td>13.8</td>
<td>13.7</td>
</tr>
</tbody>
</table>

**What about adults?**
- Reproduce two drawing with similar angles
  - Wheel:
    - Accuracy ~5°
  - Street:
    - Error: 32°

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

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

- Chinese painting refuse extrinsic, only essential
- No shadow

Retinal image

- Impressionism

- 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”
- 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

**Mirror experiment:**
- Draw your face on a mirror
- Measure: the drawing is ½ your face
- However, you see “full 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**

- Sargent
- White in light and in shadow
**Color constancy**
- Chromaticity of light sources vary
- Chromatic adaptation
  - Similar to white balance on camcoder
  - Different films, filters

**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
**Constancy & Pictures**

- Estimate slant of depicted objects
- Different real viewing angles

**Importance of frame**

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

**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

Breaking size constancy for symbol
- Middle-age
- Size = social importance

Color constancy and pictures
- Chromatic adaptation with respect to picture object, not with respect to dictated scene

Size constancy dissonance
- Surrealism (Magritte)

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